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Foreword

Welcome to Volume 8, Number 1 of the *Extension Farming Systems Journal*. This edition contains some Research Forum papers presented at the 2011 APEN National Forum 'Hitting a moving target: Sustaining landscapes, livelihoods and lifestyles in a changing world' on the 29th and 30th November 2011 at the University of New England, Armidale NSW.

The Research Forum Section publishes outcomes of research in extension and contains papers which have been subject to a blind reviewing process by two independent reviewers. The Industry Forum Section is a forum for publishing papers on extension practice, case-studies and stories. EFS will remain an on-line journal, although hard copies can be purchased at $25 per copy plus postage.

Roy Murray-Prior
Neels Botha

Editors

The character of the Extension Farming Systems Journal

The *Extension Farming Systems Journal* is jointly published by the Australasian Farm Business Management Network (AFBMN) and the Australasia-Pacific Extension Network (APEN) with free online access to AFBMN and APEN members and others. A printed version is available to interested individuals and organisations by paid subscription. The journal is registered as with DEST as satisfying the refereeing requirements for the Higher Education Research Data Collection.

Extension Farming Systems Journal is an innovative extension publication of the AFBM Network and APEN. This journal covers extension aspects of agribusiness systems. Extension Farming Systems Journal is for farmers, farmer groups, corporate agribusiness managers, professional farm business consultants, extension and development officers, academics, researchers and postgraduate students who want to help extend the available knowledge about the efficient and effective operations of farming systems in Australia. There are two formats for publication:

Extension Farming Systems Research Forum
Extension Farming Systems Industry Forum

Extension has many definitions but to provide guidance we will adopt that found on the Australasia Pacific Extension Network website (**http://www.apen.org.au**).

Extension Farming Systems Research Forum

The Research Forum section of the journal will publish research into agricultural extension issues that follow a recognised disciplinary research methodology. It is targeted at professional extension practitioners and will be reviewed by the Editors and members of the Editorial Board. Two Editors are appointed and Editorial Board members are nominated by the AFBM network and APEN. The Editorial Board manages the Research Forum and the Editorial Board members have advisory, mentoring and refereeing roles. The Executive Editor manages the printing of the Journal.

Extension Farming Systems Industry Forum

The Industry Forum section of the journal - mainly targeted to professional farmers, agribusiness managers, farm business consultants and extension practitioners - will be reviewed by an industry panel to evaluate scholarship, readability, relevance to industry and capacity to enable change. The Industry Forum section of the Extension Farming Systems Journal will publish papers on farm business and farming systems technology highlights (typically with an extension character), outstanding farm and agribusiness case-studies and leading farmers' stories.

Who can access the Extension Farming Systems Journal?

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Who can publish in Extension Farming Systems Journal?

Extension Farming Systems Journal is for members of the AFBM Network and APEN. Anyone intending to publish a paper in Extension Farming Systems Journal who is not a member of either organisation should initially apply for membership of the AFBM Network or APEN by contacting the Administrative Assistant of AFBMNetwork at afbmnetworkexecutive@listserv.csu.edu.au or the APEN Secretariat at **info@apen.org.au**

Initially the Journal Editors will decide whether a paper and author meets the criteria for acceptance into the reviewing process for either the Industry or Research Forum sections. The criteria for assessing suitability will vary according to the details outlined under the Industry and Research Forum sections of the Journal.

If accepted for the Research Forum it will be sent to two members of the editorial board for review. The Editors will then decide whether to publish a paper after receiving reports from the referees. If accepted for the Industry Forum it may be sent to reviewers from the Industry Forum panel for consideration and then published if their comments are favourable.

To submit a paper for publication please send an electronic copy of your paper, edited as per Instructions to the Editor at: Roy@agribizrde.com.

Reasons for the use, or otherwise, of soil and petiole nutrient testing by Australian wine grape growers

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Abstract Current wine industry best practice is for wine grape growers to base their fertiliser and nutrition management decisions on soil and petiole test results. Yet industry surveys have found that only a small proportion of growers regularly use these tests. In this qualitative study 45 wine grape growers from cool, warm and hot climate wine grape producing regions in southeast Australia were interviewed on their use of soil and petiole testing, in order to explain why, and when these growers used, or did not use, soil or petiole tests. We found that some growers only used soil or petiole testing once, seeking the benefit of accurate information to enable them to determine what nutrition inputs to incorporate into the soil when establishing a vineyard, or to enable them to diagnose a vineyard problem. Other growers used testing for one to four years (short-term use) "to get a handle" on a new vineyard or to evaluate changes in vineyard conditions or management. A few growers tested regularly on a continuing basis (long-term use) to monitor a problem, guide their fertiliser inputs or to ensure there were no nutrition problems arising (risk management). Some growers did not perceive that they needed the information provided by soil and petiole tests. These growers had extensive experience in growing vines, or had inherited established vineyards. They stated that they used the same nutrition program each year, were satisfied with the performance of their vines, and did not have any nutrition related problems.

Keywords: adoption, soil testing, petiole testing, nutrition, wine grapes, viticulture, Australia, market segments.

Introduction

Grape vines must have access to adequate nutrition in order to grow a marketable wine grape crop (Robinson 1992; Singh 2006). Nutrient deficiency can lead to stunted vine growth and subsequent loss of yield (Robinson 1992; White 1997). Too much nutrition may cause excessive vine vigour and the appearance of toxicity symptoms, as well as unnecessary expense and the leaching of nutrients into the environment (Robinson 1992; White 1997; Singh 2006).

The most common way to determine the nutrient levels of vines or soils in vineyards is to conduct petiole (vine leaf stem) tests or soil tests, or both. Typically, petiole and soil samples are collected in vineyards by grape growers and submitted to a laboratory for analysis. Soil samples are analysed to determine micro-nutrient, macro-nutrient, pH and salt levels. Sometimes, depending on the service provider and service purchased, other characteristics such as organic matter content are also tested. Vine petioles are analysed to determine the micro-nutrient and macro-nutrients levels in the vine (Robinson 1992; Cooperative Research Centre for Viticulture 2006). The results of the tests are then compared with industry standards for grapevines (Swinburn and Saris 2005).

The Cooperative Research Centre for Viticulture and the Department of Primary Industries Victoria recommend as best practice that wine grape growers base their nutrition management decisions on the results of annual soil and petiole tests (Robinson 1992; McConnell et al. 2003; Cooperative Research Centre for Viticulture 2005). In a previous paper (Hill et al. 2009), we found that grape growers adopted nutrition-related products, primarily fertilisers and mulches, for two key reasons. The first was to optimise the establishment and growth of young grape vines. The second was to manage established vines to meet their vineyard production objectives. Overall, growers considered the nutrition-related products and practices that were available to be satisfactory for optimising the growth and establishment of young vines. Consequently, we concluded there was little need for research into new products in this area.

Growers reported that they experienced a number of nutrition-related problems in regard to their established vineyards. These problems concerned nutrient availability, soil health and modifying wine grape quality. However, despite these problems and in disregard of best practice recommendations, industry surveys have found that only a relatively small proportion of grape growers regularly used testing, even though between 50 and 75 per cent of grape growers have had soil and petiole tests carried out at some stage (Hood et al. 2003; Swinburn and Saris 2005). Our purpose in this paper is to explain why and when wine grape growers used soil and petiole testing.

Background

Growers test soil and leaf petioles because the resulting information offers some kind of benefit in their management of vines and vineyards. Presumably, differences in growers' use of soil and petiole testing result from differences in their perceptions of the management benefits from testing. Consequently, explaining differences in adoption of soil and petiole testing depends on identifying the benefits growers seek from the tests, and identifying the aspects of the farm context that influence the magnitude of these benefits.

A search of the literature did not reveal any published papers on the adoption of soil and petiole testing in viticulture. However, the adoption of soil testing has been studied in other agricultural industries (King and Rollins 1995; Contant and Korsching 1997; King 1999; Srivastava and Pandey 1999; Bewsell and Kaine 2001; Kremer et al. 2001; Napier and Tucker 2001; Yadav et al. 2006; Walton et al. 2008; and Fe`li et al. 2010). Generally speaking, these studies have found the adoption of soil testing was influenced by a variety of factors including: knowledge of soil sampling principles (Fe`li et al. 2010); timeliness and reliability of tests (Yadav et al. 2006); age, education level, size of farm and economic situation of the farmer (Contant and Korsching 1997; Kremer et al. 2001; Walton et al. 2008; Fe`li et al. 2010); and the type of communication used by, and attitudes of, extension agents (King and Rollins 1995; King 1999)

With the exception of farm size and the timeliness and reliability of tests these factors, by and large, are likely to influence the rate of adoption of soil testing rather than influencing the benefits or relative advantage soil testing might provide. Bewsell and Kaine (2001) investigated the use of soil testing by Victorian vegetable growers. They reported that the specific management benefits these vegetable growers sought from soil testing were to tailor crop fertiliser programs, to monitor nutrition problems, to identify and detect the emergence of new problems, and to manage product quality.

Method

Many models of adoption have been proposed (Ajzen 1971; Rogers and Shoemaker 1971; Fishbein and Ajzen 1975; Bandura 1977; Chamala 1987; Davis 1989; Bagozzi 1992; Rogers 1995; Abadi Ghadim and Pannell 1999). These models vary in their complexity; the stages in the adoption process they distinguish, the sophistication with which they describe the processes at work in particular stages, and their generality. All of these models propose that the adoption of an innovation is a function of the producer's perception of the degree to which the innovation offers a relative advantage, that is, contributes to the achievement of their goals (Lindner 1987; Pannell 1999).

However, all these adoption models are constructed on the assumption that the elements in the producer's context that influence the extent to which an innovation promises a relative advantage can be identified using a process of discovery that is external to them. While some of these models offer extensive suggestions as to the various elements in the context that may influence decisions, they do not contain mechanisms for identifying precisely which elements are influential for a particular innovation. Consequently, these models of adoption cannot be used in isolation to identify the population of potential adopters of an innovation.

Kaine (2008) described a method, underpinned by concepts from consumer behaviour theory and farm systems theory, for analytically identifying the factors in a producer's context that influence the relative advantage offered by an agricultural technology or practice. The method has been applied to a variety of agricultural technologies and practices in a number of industries. In short, the adoption of soil or petiole testing by grape growers will depend on the extent to which growers believe these tests offer them a relative advantage. To identify the factors that influence grower's perception of the extent to which soil and petiole tests would offer a relative advantage we followed the method described in detail by Kaine (2008).

The method uses laddering (Grunert and Grunert 1995) and convergent interviewing, a dialectical process (Dick 1998) to similarities and differences in the reasoning underlying the decisions and actions of producers. Laddering is used in personal interviews with a producer to elicit the reasoning underpinning their decision to use, or not, the technology or practice of interest. Similarities in the reasoning of producers should result in similar decisions. Differences in decision-making by producers should be the logical product of differences in their reasoning. Producers are interviewed until the point is reached where the similarities and differences in the decisions of producers are reconciled with similarities and differences in their reasoning. This is the point of convergence (Kaine 2008).

The method described by Kaine (2008) can be applied, in principle, by interviewing a random sample of producers until convergence is reached. In practice, convergence can be achieved more efficiently by interviewing a random sample of producers stratified on use or not of the technology or practice of interest, and factors that might reasonably be expected to influence the relative advantage of the technology or practice of interest such as enterprise location and size.

We conducted interviews with 45 grape growers from cool (Coonawarra, McLaren Vale, Padthaway, Yarra Valley and Wrattonbully), warm (Barossa Valley, Bendigo, Goulburn Valley, Heathcote and Strathbogie Ranges) and hot (Sunraysia) wine grape producing regions. Growers were selected to represent large, medium, small, family and corporate businesses, and a cross section of wine quality grades and price points. This number of interviews was sufficient to achieve convergence.[1]

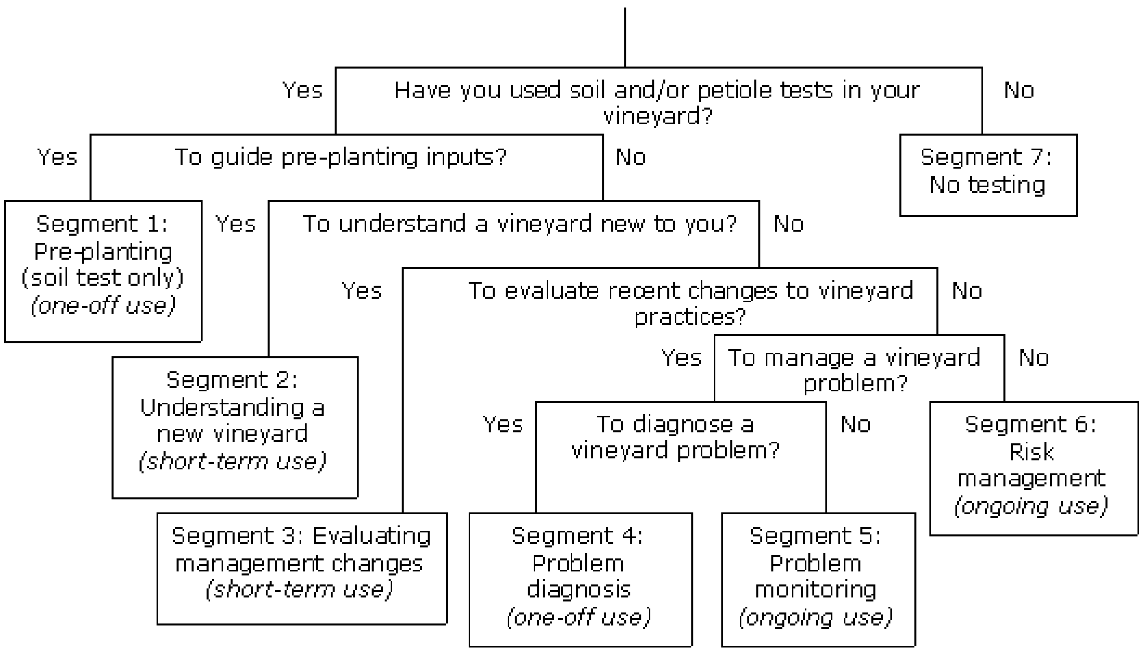
The interview data were transcribed manually with two interviewers participating in each interview. Following a dialectical process, the responses of interviewees were analysed and summarised using case and cross-case analysis as each interview (case) was completed (Patton 1990). Growers were classified into benefit segments for soil and petiole based on their reasoning for using testing, or not, as described next.

Results and discussion

The growers that used soil tests and petiole tests did so seeking a range of benefits. These benefits varied depending on a number of contextual factors, such as the age of the vineyard, and if the grower was seeking to evaluate management changes or to diagnose a problem, and provide the basis for classifying them into benefit segments (see Figure 1). The benefits sought influenced if the growers would use the tests only once, for a limited time, or as a long-term decision support tool. Interestingly, reducing the risk of nutrient losses to the environment did not emerge as a critical reason for regular use of soil and petiole testing. This suggests that efforts to promote regular soil and petiole testing on the grounds of environmental best practice are unlikely to meet with success.

It was possible for individual growers to be in two or more segments simultaneously depending on the nature of their vineyard. For example, a grower could be a member of segment 1 (soil test pre-planting) if they were establishing a new block in their vineyard, and at the same time, be a member of segment 6 (petiole test annually to monitor nutrition) for established blocks in their vineyard.

Figure 1. Market segments based on the benefits sought by growers by soil and/or petiole testing



[1] The data for this paper was collected during the interviews in which we collected the data analysed in Hill et al. (2009).

Description of benefit segments[2]

Segment 1: Soil test pre-planting

Almost all of the growers interviewed tested their soils prior to planting new vines. The benefit of this was to determine accurately the type and amount of inputs such as fertiliser, gypsum and lime they should incorporate, often by deep ripping, into the soil prior to planting. Incorporating the correct nutritional inputs was seen as important by these growers in order to optimise vine establishment and survival, and to minimise future nutrition related problems. Some growers who conducted pre-planting soil testing did not retest the soil again later.

Laura, a grower from the Strathbogie Ranges said:

> *"I had the whole vineyard site soil tested before I planted. I wanted to make sure that I got the right amounts of lime, gypsum and superphosphate down the rip lines to give the vines a strong start. If you miss that chance you will run into problems later, and will always be trying to fix something up that you should have taken care of before".*

Most of the growers interviewed said that they were satisfied that the soil tests provided them with the information they needed in this regard. A few growers reported that they believed they had received incorrect recommendations, possibly because the test results had been misinterpreted.

Segment 2: Understanding a new vineyard

Some growers used soil and petiole testing in the short-term to "get a handle on things", that is, to obtain information about a vineyard that was new or unfamiliar to them. The growers in this segment tended to use soil and petiole tests for one to four years, after which they said they understood the nutritional requirements of their vineyard and how their soil and vines responded to the fertilisers and products they were using. Testing over this period gave the growers the confidence that their nutrition program was working and they were not going to run into serious nutrition problems in the future.

Michael, a Bendigo grower, used petiole testing while he was new to the vineyard:

> *"I've done petiole analysis in the past. It definitely helped us set our fertiliser program. We have got a handle on it now though. We were getting the same results all the time and the site has fairly well balanced vines, so it's not worth testing anymore".*

Tony is a Sunraysia grower, with vineyards on three different properties. Tony said:

> *"I used to monitor the water and do soil and petiole testing. It gives you the information to make sound, informed decisions. But with falling grape prices and rising costs I don't do it anymore. The soil tests always came up good, and never identified any problems. I kept doing petiole tests until I saw the trends, and until I got a good handle on it. You need to combine science with experience to be successful".*

The growers in this segment said that testing provided them with the information they needed.

Segment 3: Evaluating management changes

Growers in the segment describes as 'Evaluating management changes', also used soil and petiole testing for a limited period. The benefit of using testing for these growers was that it enabled them to evaluate and understand the impact of management changes they had made in their vineyard, either on the soil characteristics (soil test), the vines nutrition status (petiole testing), or both (soil and petiole test). Examples of the management changes they evaluated were using a new fertiliser, or changing the rate of a fertiliser, mulching, or installing drip irrigation. These growers used the tests for a few years until they felt that they "had a handle on things" and understood the implications of the changes they had made. They then ceased testing.

For example Bill, who has a vineyard in Sunraysia, told us:

> *"When I installed drippers I had soil pits dug and the soil tested. I wanted to know if the new irrigation system would affect the nutrient availability of my soil. It turned out I've got uniform soils and changing to drippers didn't have enough effect (on nutrient availability) for me to need to change my fertiliser program".*

[2] Names are fictional.

Hayden manages vineyards in the Coonawarra region. In recent years organic sprays, mulches and manures have been included in his nutrition program and he was interested to know if these changes had improved soil health and nutrient status. Hayden said:

> *"We are trying to go for softer options now, conventional (fertilisers) are not as good for soil, they kill off the bacteria and fungi in soil, which damages the soil structure and reduces nutrient uptake. I will do a soil test this year which will include a biological test because I haven't done one for a while and I want to know if these (organic) products are helping".*

Growers in this segment had not experienced any problems with soil and petiole testing.

Segment 4: Problem diagnosis

Growers in the 'Problem diagnosis' segment used the tests to try to determine why vines were looking unhealthy or weak, for example if vine growth was sparse or the leaves were discoloured. These growers said that when they found unhealthy vines, they first checked the vines' roots for damage and then conducted soil and petiole tests to determine if the cause was nutrient or soil related.

For instance Chas, who grows vines in the Goulburn Valley, said:

> *"I had a soil test done because I had a problem in the vineyard and was trying to rule out a number of possibilities. I'd looked at the roots, water, soil and weeds, but there was no problem with these so I thought I'd better look at nutrition. I tested an area of healthy and an area of sick vines and the tests results all looked the same. This made me realise it may be a pest issue. It turned out that the sick vines were infested with phylloxera".*

Dave grows red wine varieties in the Barossa Valley, Dave said:

> *"If I see an issue with my vines I get a petiole test done. I tested some Shiraz five years ago, the test showed the vines had a boron deficiency. I had a feeling that was the problem because the vines looked so ordinary. The test confirmed that that was the problem".*

The benefit growers in this segment sought from soil and petiole testing was identification of the cause of their vine health problem. If the problem was nutrition related, the growers then wanted to know which fertiliser or soil treatments would effectively solve the problem. Growers in this segment observed that the benefits they sought from soil or petiole testing were not realised if:

- There was more than one factor causing the problem with vines.
- The cause was related to nutrition, but the vines were not flowering, so petiole testing could not be conducted.
- The test recommendations were inaccurate, incorrect or not suited to the site.

Discussion on one-off and short-term use of testing

The growers in Segment 1 and Segment 4 used soil and petiole tests once. These findings are consistent with those of Bewsell and Kaine (2001) who found that some vegetable growers only conducted soil tests when planting on a new block of land.

Growers in Segment 2 and Segment 3 used the tests in the short-term (one to four years) to enable them to "get a handle on things" when managing a new or unfamiliar vineyard or evaluating management changes. These growers were satisfied that the tests had helped them achieve that. Bewsell and Kaine (2003) found that grape growers in New Zealand used soil moisture monitoring for some years until they were confident with their vineyard irrigation and soil. Like the wine grape growers in Segment 2 and Segment 3, the New Zealand growers ceased using the technology when they felt they "had a handle on it".

The growers in segments 1, 2, 3 and 4 have used testing to resolve a problem with production. They then cease testing because they do not perceive any further benefit to be had from testing. In effect, the growers in these segments are likely to become members of segment 7 once they discontinue testing. Conversely, under the right conditions, growers in segment 7 are likely to be, or become, members of any or all of segments 1, 2, 3, or 4. There is then, an exchange of members between segments 1, 2, 3, 4, and 7.

Kremer et al. (2001) found a similar pattern in the adoption and use of the N-track self-administer soil nitrogen test amongst Iowan farmers who initially adopted the technology then discontinued use after a few years. These farmers perceived that the N-track had enabled them to obtain a good understanding of their crop nitrogen requirements.

The short-term use of the tests does not represent a failure of the technology, but rather demonstrates that use of the tests had provided the information the growers required. Once the growers' information needs had been met, the cost of further testing outweighed the benefits received and hence the grower ceased using the tests. The growers from these segments said they would use soil or petiole testing again if they were to experience a nutrition problem in the future. This has two important implications from an extension perspective.

The first implication is that the appeal of extension messages promoting the use of soil and petiole testing could be broadened if messages included content highlighting the benefit of testing when establishing new vines and testing to diagnose and resolve problems with vine health (e.g. McConnell et al. 2003).

The second implication concerns the value of promoting the regular use of soil and petiole as a best management practice to improve productivity. That growers used soil and petiole testing to meet a short-term need but then abandoned it, suggests that most growers possess the knowledge and skills to successfully adopt and implement the testing technology.

Consequently, the failure of growers in segments 1, 2, 3 or 4 to use the technology cannot be attributed to some lack in their appreciation of, or capacity to implement, soil and petiole testing. It seems reasonable to presume that, had they experienced substantial reductions in grape yield or quality once they discontinued testing, these growers would have resumed regular testing. In other words, the failure of the growers in these segments to continue regular testing suggests that, once they had stopped testing, they did not detect a decline in grape yield and quality sufficient to convince them that it would be worthwhile to resume testing. The experience of these growers is, then, that regular soil and petiole testing is not worthwhile for mature vines in good health.

Therefore, growers who test once, or for a short time only will be unlikely to respond to extension messages seeking to promote regular testing as best management practice for productivity. Such messages contradict their experience. At best, they will disregard such messages, regarding them as not relevant to their circumstance, unless it can be demonstrated that continued testing would generate a substantial improvement in production performance of mature vines. Such messages could cause growers to question the credibility of the source of these messages.

Segment 5: Problem monitoring

Growers in the 'Problem monitoring' segment regularly used soil and petiole tests to monitor a long-term problem they were experiencing (such as soil salinity or nutrient deficiencies), or a situation they believed could develop into a problem (such as acidity levels). The growers in this segment indicated that they had identified the source of the nutrient imbalance, hence they were not members of Segment 4, and while they may be adjusting their fertiliser program to address the nutrient imbalance, they were not planning major management changes (Segment 3).

An example of a grower in this segment was Sarah who manages a Coonawarra vineyard. Sarah said:

> *"We are worried about our soil salinity levels, so we soil test regularly. We also use soil tests in problem areas to confirm petiole test results, which we conduct every year. We use petiole tests mostly because they have standards and they give us a better indication of what the plant has taken up, rather than what is there (in soil) but not available. We just want to make sure things are not getting out of hand".*

Segment 6: Risk management

Growers in the 'Risk management' segment had tests done regularly to monitor conditions in their vineyard, even though they do not have any significant soil- or nutrition-related problems. The growers said that the benefits of doing this were that they had peace of mind that their vines' nutrition needs were being met, that their production goals (yield and quality) would be achieved, and that they would not be caught unprepared by any nutrition related problems. Other growers in this segment used soil and petiole test results when liaising with vineyard owners, chief viticulturists, finance managers or wineries about grape quality, vineyard planning or management or budgets. Essentially an unexpected nutrition problem poses a major risk for these growers and soil or petiole testing can easily and inexpensively manage this risk.

Kingsley runs a vineyard in Heathcote. Kingsley told us:

> *"We base our rate of fertiliser application on soil and petiole tests, and test nine out of seventeen blocks each year. In April we soil test and put out any necessary*

> *ameliorations we need to meet our production targets. The test results enable me to convince the finance people we're doing the right thing, and get the fertiliser allowance we need".*

Discussion on long-term use of testing

The growers in Segment 5 and Segment 6 used soil or petiole testing regularly for long periods, which is recommended best practice, and said they found the information valuable in enabling them to monitor problems or manage production risks. Likewise, Bewsell and Kaine (2001) reported that some Victorian vegetable growers used soil testing regularly to determine the nutrient status of their soil and tailor crop fertiliser programs accordingly, or to monitor nutrition problems. They found that soil moisture monitoring was regularly used by wine grape, fruit and vegetable growers to identify and detect the emergence of new problems, to monitor existing problems, and to manage product quality (Bewsell and Kaine 2001, 2003; Kaine and Bewsell 2001a, 2001b; Kaine et al. 2005).

The implication of this behaviour is that, unlike the growers in the other segments, growers that regularly use testing view the costs of regular testing as less than the anticipated costs of correcting any nutrient-related problems in production that might appear in the future. However if these growers start to perceive that the cost outweighs the benefit gained through testing, they will cease testing. This may be due to the emergence of a new technology or service that provides the information they require more quickly, cheaply or efficiently, or the problem they are monitoring or risk they are managing may dwindle in importance.

Segment 7: No testing

The growers in 'No testing' segment had not used soil or petiole testing and had either inherited established vineyards or had extensive experience in growing vines in their vineyard. These growers said that they used the same nutrition program each year, and, if any problems had occurred, they had been able to identify the cause of the problem and solve it. Consequently, they may, at an earlier time, have been members of segments four or five. The growers in this segment were satisfied with the performance of their vineyards and said they did not require the information soil and petiole tests would provide.

Angelo is a Sunraysia grower of both wine and dried fruit grapes. Angelo said:

> *"I don't soil or petiole test, I just look at the vines. If the vines start to look poor I fertilise with nitrogen. I don't seem to have any soil or nutrition problems, the vines usually look fine".*

Another example of a grower in this segment was Bill who has been growing wine grapes in the Barossa valley for many years. Bill said:

> *"My grandfather started this vineyard in the 1920s, then my father ran it and I've run it for the last 25 years. If the cover crop looks healthy then I assume the nutrients are all right. Our Shiraz is close to top of the range so there is no reason to mess with that".*

These growers appeared to believe that soil and petiole testing was not worthwhile for mature vines in good health. Therefore, these growers will be unlikely to respond to extension messages seeking to promote regular soil and petiole testing as best management practice to improve productivity, unless the benefits can be demonstrated to them. However, if their vineyard developed a nutrition-related problem or perhaps they made management changes such as starting to mulch their vines, these growers may decide that testing would provide worthwhile information and may experiment with, or begin to use soil and petiole testing.

Conclusion and future work

Soil and petiole tests were widely used by wine grape growers when making vineyard nutrition and soil management decisions. However, only a small proportion of growers followed best practice and regularly tested on a continuing basis. We have described the reasons why this is the case.

Further research involving surveying a large sample of grape growers would be useful to quantify the numbers of growers in the segments, and statistically validate the results and conclusions reported here.

Efforts to promote regular soil and petiole testing as environmental best practice to wine grape growers may be successful. Success will depend on the extent to which each grower is concerned about nutrient losses through leaching and run-off in their vineyards and wish to minimise their use of fertilisers and if the growers regard, or can be convinced, that soil and petiole testing as useful tools in achieving this. It would require further social research to determine growers' attitudes about this topic.

The use of other available agronomic tests, such as sap testing or leaf blade analysis could be investigated in the future to determine why the use of these tests is not more widespread. The existence of patterns in the reasons for using management tools, such as soil and petiole tests and soil moisture monitoring, across horticultural and other agricultural industries may be worth further research.

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Benefit-cost analysis of addressing rural diffuse pollution through the FarmFLOW Extension Framework

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Abstract. Since the early 1980s the international community and government at all levels have become increasingly aware of the off-site impacts of agriculture. It has been argued that concepts of stewardship are insufficient to drive practice change and that the underpinning economic and social drivers for farm management practice need to be considered. This article argues that increased public investment in voluntary extension programs that target high risk agricultural sub catchments is an economic efficient intervention to reduce rural diffuse pollution. The analysis assessed the economic impact of investing in the FarmFLOW area-wide management framework in coastal South East Queensland. This approach focuses on voluntary adoption within an integrated catchment management context. The study modelled the impact of reduced off-farm flows of sediment and nutrients based on anticipated increased adoption of a limited number of recommended best management practices. The study showed that a voluntary extension approach supported by incentives and investment in on-farm trials, demonstration and action learning would have a positive internal rate of return of 13.4% from the ongoing investment by government with a benefit-cost ratio of 1.61.

Key Words: benefit-cost analysis, natural resource management, public goods, sustainable, environmental and ecological economics, agricultural policy.

Introduction

Concerns regarding the off-site impacts of agriculture came to prominence in the early 1980s. In Australia the early impetus for current action was driven by the investigations of the Advisory Committee on the Effects of Agricultural Practices on Coastal Zone Ecosystems (1992). They suggested that the responsibility for, and costs of, minimising downstream effects should not fall disproportionately on the rural sector and recommended appropriate and equitable forms of compensation to farmers and agricultural industries.

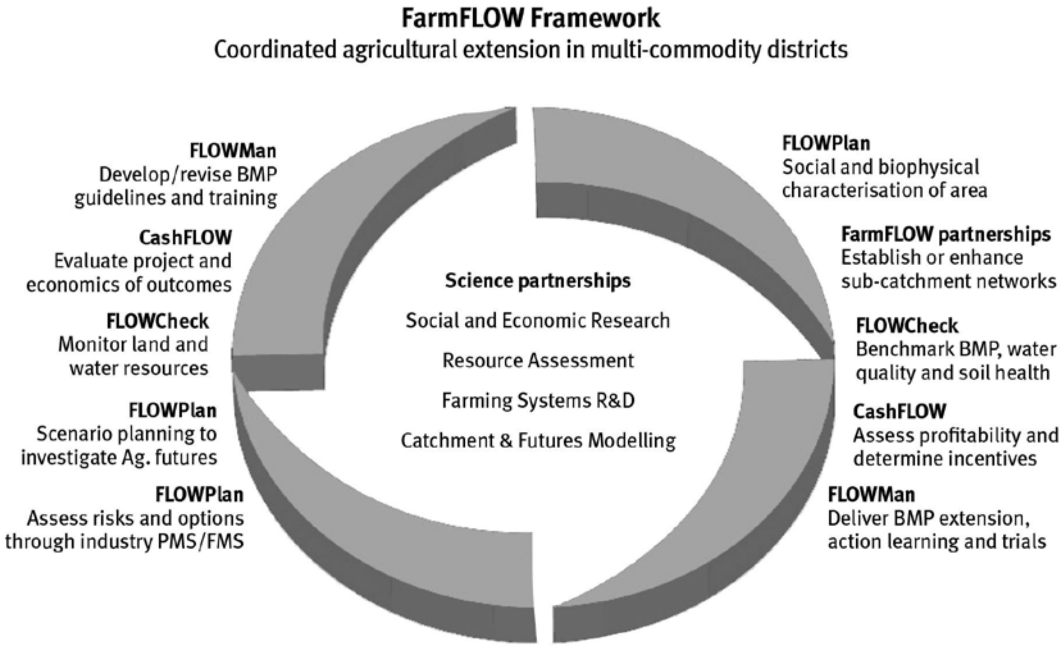
Over the last twenty years Australian governments have introduced a range of policies and incentives to address the 'spill-over effects' of agriculture through stewardship programs such as Landcare and then integrated catchment management programs (Burton 1991; Dawson 1993; Mitchell & Hollick 1993). Lawrence et al. (2003) argue that concepts of stewardship are insufficient to drive practice change. Consequently, it has been broadly argued that the key to achieving ecologically sustainable primary production is to develop and implement systems that contribute to desirable social and economic outcomes for the whole community while minimising environmental harm.

More recently, the Queensland and Australian governments have invested in both voluntary and regulatory measures to improve water quality flowing both to the Great Barrier Reef Lagoon and Ramsar listed waters of Moreton Bay (GBR Reef Protection Interdepartmental Committee Science Panel 2003; Healthy Waterways Partnership 2007; Anon 2009; Stockwell 2010). The relative efficacy of voluntary versus regulatory approaches (e.g. Weaver et al. 1996), compulsory Pigovian taxation versus voluntary incentives (e.g. Sun et al. 1996) and market based instruments (e.g. Clowes 2004) are a recurring topic for analysis in resource economics literature. Equally, the relative effectiveness of different models of farmer engagement to drive practice adoption is a frequent subject of concern to rural social scientists (e.g. Pannell & Vanclay 2011).

It is within this context that the FarmFLOW extension framework (Figure 1) was designed to address the problem of sediments, nutrients and pesticides running off and leaching from rural land into waterways, aquifers, estuaries and bays (rural diffuse pollution). It was developed with the social, economic and landuse characteristics of peri-urban agricultural catchments of South East Queensland (SEQ) in mind. FarmFLOW is a voluntary adaptive management approach underpinned by rapid rural appraisal and multi-commodity extension processes that use a range of social and economic techniques (e.g. decision support tools, grants and incentives) to reduce the impediments to the adoption of best management practices by commercial producers. The framework also features paddock and subcatchment scale monitoring of land and water resources and annual benchmarking of practice uptake to evaluate the impact of the intervention.

This article firstly reviews the economics underpinning initiatives to address the downstream impacts of agriculture and then assesses the costs and benefits of implementing voluntary, area-wide management program at a sub-catchment scale based on the Phase 1 implementation of the FarmFLOW Framework (Stockwell 2009). The benefit-cost analysis sought to quantify both the on-farm and the external impact of agricultural production and projected improvements in management practices over the subsequent sixteen years, and to analyse the return on government and industry investment from a proposed second phase of this project. This research found that increased public investment in voluntary extension and incentive programs that target producers in high risk sub catchments is an economic efficient intervention to reduce rural diffuse pollution.

Figure 1. Conceptual diagram depicting major elements of adaptive management cycle in the FarmFLOW Framework



Source: Stockwell et al. in press

Literature review

The environmental effects of agricultural activities result from an integration of economic decisions, private-good production practices and biophysical processes that involve both the long-run and short-run production decisions of farmers (Weaver 1996)**.** There is also a role for economics in quantifying the environmental costs and benefits that occur outside the private entities that produce them. Sediments, nutrients and other pollutants that move off farms frequently lead to downstream water quality problems, or rural diffuse pollution, which is a common externality of agriculture.

In the short to medium term, non-sustainable agriculture can lead to inflated profitability in agriculture derived from the cumulative depreciation of the environmental asset reserves. Sediment and nutrient loss from farms is a good example of a cost that is external to agriculture that may not have immediate impacts on the producer's bottom line but comes at a public cost. In Australia, cropping and grazing are significant contributors to nutrients and sediments in inland waters and coastal pollution (Hamilton & Haydon 1996; Wason et al. 1996, National Land and Water Resources Audit 2001).

Tietenberg (1992) argues that the creation of negative externalities (pollution) by privately owned agricultural production entities, can be linked to the following factors (or the perception of them):

- The output of the agricultural product is too high because the external costs are not borne by the primary producer; hence, too much pollution (soil and nutrient loss) is generated.

- The price of agricultural products is too low, as they do not include the external costs, creating greater demand (consumption) through imperfect market signals.
- The failure of agriculture to 'internalise' external costs leads to underinvestment in the search for ways to reduce the external costs.
- Recycling & reuse of the items or materials causing the external costs is discouraged.

Mitigation of soil loss is expensive and fertiliser is a relatively cheap method of replacing lost nutrients. Although sediment loss represents a cost to producers in the form of some lost production capacity, and perhaps an increase in fertiliser costs, the overall cost to the business is minor and usually ignored. Damage caused downstream by soil loss is not borne by the agribusiness and therefore the impetus for practice change is minimal. Trapping and recovering sediment that depreciates the environmental asset and creates the external cost is discouraged, hence, there is underinvestment in possible solutions (Tietenberg 1992). Yet the cost paid by water users on the streams, rivers and oceans of the world can be significant. This cost is paid as a loss of amenity, reduced recharge of aquifers, higher filtration costs for water users, algal blooms, reduced fish stocks, loss of habitat, and reduced recreational and/or business opportunities (e.g. Blamey 1992; Sun et al. 1996; Wossink & Osmond 2002).

The valuation of ecosystems services affected by soil erosion and nutrient leaching can inform the estimation of non-market valuation of externality costs. For example, Brenner et al. (2010) estimated a value for soil formation in cropping land to be $7 USD per ha/year. While dated, the most relevant research was a case study of the Willamette Valley in Oregon USA, which estimated the off-site costs of soil erosion from agriculture (Moore & McCarl 1987). That analysis estimated the annual average erosion costs to municipal water treatment, road maintenance and navigation channel maintenance of $6.50 USD per hectare of agricultural land per year (present value 2010). This figure was used as the basis for estimating societal benefit in this study.

Paton and Grice (2004) suggest that much of the emerging sustainability in agricultural effort is driven by the desire of producers to meet industry best practice, to have minimal environmental impacts, to be economically viable and to be acknowledged by the broader community as effective land managers. The drivers for practice change internal to private entities involved in agricultural production will take one of three forms, or a mix of all three:

- Profit Driver – A demonstrable economic benefit is derived from the implementation of the practice change to the private business.
- Risk Reduction Driver & Associated Social Benefit Driver – Practices which can be shown to reduce risks to the enterprise and/or the desired social attributes of the family farm, including workplace amenity.
- Subsidy Based Driver – Practice change is facilitated through payment of subsidies to compensate the private business to undertake 'public benefit practices' in the absence of real or perceived private economic benefit accruing from the change.

While the adoption of recommended Best Management Practices (BMP) is promoted as an effective mechanism to reduce the externality costs of agriculture, there are rational reasons for farmers not to adopt BMPs that reduce rural diffuse pollution. Rolfe (2002), for example, points out it is not always financially attractive for landholders to pursue sustainability goals when there are long lead times involved in future production losses.

From a sociological perspective, adoption of BMP is a dynamic learning process strongly influenced by personal, social, cultural and economic factors, as well as the intrinsic characteristics of practice or innovation. Adoption more readily occurs:

- When there is a perception of a net benefit or contribution (i.e. relative advantage) to the achievement of personal / end goals that include economic, social and environmental values.
- When practices/innovations are easy to test and learn about prior to their adoption (high 'trialability') (Pannell 2006).

Marshall (2008) found that scale in extension delivery was important, identifying that subregional natural resource management groups have been more successful than regional bodies in motivating voluntary cooperation from farmers in adopting practices because of their ability to engage effectively and establish trust from their farmer constituents such that they come to follow reciprocity strategies.

Sun et al. (1996) found that due to specific production practices, a particular group of farmers within their study area could reduce nitrogen leaching and runoff more efficiently than others. Their economic simulation of expected returns suggested that a government cost-sharing program that provided incentives to farmers for voluntary adoption of economically efficient and environmentally acceptable BMPs would be superior to an alternative scenario of regulating/penalising all producers in the watershed using a tax on fertilisers. Clowes (2004) also point out that there are several constraints to imposing regulatory controls on non-point source pollution such as the difficulty in establishing liability in enforcement processes. This is complicated further by the technical difficulty in establishing the timing of the initiation of the problem and the responsible individual/ entitywhen property rights can be transferred. He also suggests that the challenge of monitoring compliance at a reasonable cost is a primary concern.

The socio-economic context of BMP adoption, as outlined in the above review, was overtly considered during the design, piloting and implementation of the FarmFLOW Framework in South East Queensland, Australia. That framework was developed to respond to the persistent water quality problems identified by a long-term Ecosystem Health Monitoring Program in South East Queensland. This socio-economic context guides interpretation of the costs and benefits of investing in voluntary programs that target agricultural producers in high-risk sub catchments.

Study Area

Long-term monitoring of the catchments of SEQ has shown that a significant contribution to the loads of pollutants entering Moreton Bay originate from the rural landscape (73% of sediments, 36% of Nitrogen) (WBM 2005). In addition, annual evaluations of the major agricultural catchments in the region consistently show poorer freshwater and estuarine water quality than those where primary production is only a minor activity (EHMP 2004, 2005, 2006, 2008).

In 2006 the Queensland and Australian governments jointly prioritised rural diffuse pollution in the revised Regional Water Quality Improvement Plan (Healthy Waterways Partnership 2006). Since then they have provided significant funding for the implementation of the FarmFLOW as a key element of the response. Evaluation of best-practice adoption and economic and biophysical analysis of the impact of this intervention has shown promising results in reducing the threat to downstream environments posed by sediments and other nutrients known to be driving blue-green algal blooms in the Pumicestone Passage (Hannigton 2007; Stockwell et al in press).

To date, estimation of the value that the SEQ community places on maintaining and rehabilitating wetlands and waterways has been undertaken through citizen's juries, surveys and choice modelling (Clouston 2001; Robinson, Clouston & Suh 2002, Binney 2010). However, more robust analyses are required by decision makers about the cost efficiency of investing in specific interventions that aim to protect or enhance these communal environmental values.

In 2010, the authors undertook a benefit-cost analysis investigating the implications of further government investment in the FarmFLOW framework to inform policy and investment decisions within government. The analysis assessed the economic impact of expanding the FarmFLOW approach from the coast sub catchments of the Pumicestone Passage to all coastal sub-catchments identified as high risk by Pointon et al (2008) in terms of their relative contribution of nutrients of concern to algal blooms in the region. This assessment showed that the coastal components of catchments within 150 kilometres north (Sunshine Coast and Pumicestone) and south (Logan-Albert) of Brisbane had the highest level of hazard. Our analysis of Queensland Government GIS databases indicated that high-risk sub catchments on the Sunshine Coast, Pumicestone and Northern Gold Coast featured approximately 9,200 ha of horticulture and cane production.

Method

The study modelled the impact of reduced off-farm flows of sediment and nitrogen based on an anticipated increase in adoption of a limited number of recommended BMP. The analysis aimed to:

1. Estimate the net benefits and costs that would be incurred internally (on farm) in minimising the environmental impacts of excessive soil erosion and off-site flow of nutrients.
2. Provide an estimate of the environmental/public benefit that would accrue if adoption of practice change increased across relevant industries in the target region and environmental outcomes were improved.
3. Analyse the 'return on investment' of increased public funding for the FarmFLOW extension framework as a delivery mechanism.

The analysis was based on a scenario of increased government investment in the FarmFLOW framework for an additional eight years in order to achieve a target of 80% of farmers adopting recommended BMP. However, on-farm costs and benefits were estimated out to the 2026 time horizon of the SEQ Healthy Waterways Strategy (Healthy Waterways Partnership 2006). In estimating the on-farm costs and benefits of implementing practice change, the study considered all identifiable parameters affected by implementing practice change, such as yields, inputs (fertiliser, pesticides, labour) and capital investments (e.g. fencing, machinery).

This study commenced with capturing baseline data and refining study parameters including:

- Identifying the high risk sub-catchments to be targeted for potential expansion based on the hazard assessment of Pointon et al.(2008).
- Consulting with relevant extension officers to determine the industries and practices (BMPs) of relevance to individual sub-catchments.
- Collating data from trial results reported during Phase 1 of the Healthy Country FarmFLOW project that quantified soil and nutrient savings from specific BMPs (see Factsheets at Anon 2010a).
- Accessing government GIS land use databases to determine the spatial extent of each industry (cane, strawberries, pineapples) in each catchment, the average farm size for use in gross margin analysis, and the number of farms for use in the adoption profile.

These data were used to refine existing gross margin and partial budgeting economic analysis tools (e.g. the Cane Farm Economic Assessment Tool described by Stewart (2010)) and to construct a benefit-cost analysis spreadsheet for calculating both the aggregate on-farm costs and benefits of practice adoption, and the average biophysical impact of this per farm (e.g. sediment and nutrient savings).

The SEQ ABCD Classification System (Anon 2010b), which is a system based on the method originally developed by Drewry et al. (2008), was used to establish relevant BMP and to?? benchmark practice adoption. The benefit-cost model utilised partial farm budget comparisons to assess the financial impact of farmers moving away from dated practices (Class D) and conventional practices (Class C) to currently recommended best practices (Class B) and in the case of cane, one Class A practice (GPS guided minimum till). These data, together with an estimate of the envisaged project operating costs required to apply the FarmFLOW framework across all high-risk sub catchments in coastal SEQ, were used to estimate potential returns on investment. A discount factor of 6% was applied to determine the present value of future anticipated cash flows.

The Revised Universal Soil Loss Equation (Renard et al. 1997) was used to estimate the soil loss from a 'typical' strawberry, pineapple and cane farm scenario in the farm partial budget model. Once in-field sediment loss rates were calculated, the net amount of sediment moving off farm and into waterways was estimated based on the effectiveness of riparian areas in filtering sediments from overland flow. The analysis was founded on Class D and C farms having poor to moderate riparian vegetation which would filter 50% of sediments, while Class B and A farms would have good riparian vegetation capable of filtering 90% of horticultural sediments (80% for cane).

To determine the flow of costs and benefits over time, an adoption profile was required. The adoption profile was created using the system dynamics model developed by Sterman (2009). This model adapts traditional theories on the dissemination of innovation based on the relative abundance of innovators, early adopters, early and late majorities and laggards (Rogers 1995). It uses two coefficients, one for innovators (p) and one for imitators (q) to generate adoption curves. The dynamic simulation runs in discrete time steps (annually) and shows that the behaviour of the system would be to have growth in adopters that follows the classical s-curve shape. Benchmark data on BMP adoption over the first three years of FarmFLOW projects was utilised to refine the coefficients such that the rising slope of the s-shaped curve closely reflected actual results from the project to date (Figure 2). The line of best fit was achieved with the innovation coefficient $p = 0.06$ and imitators $q = 0.5$.

Results

Analysis of government and industry statistics suggests that there are approximately 383 horticulture and cane farmers in the targeted high-risk agricultural sub-catchments of the Sunshine Coast, Pumicestone and Northern Gold Coast (Table 1). The modelled target was to achieve 80% of farms adopting the relevant best management practices identified in Table 2. These variables together with the collated data on the general topography of production areas and the average size of farms in the area were used to generate 'per farm' soil loss data relevant to adoption or non-adoption of the practices in Table 2.

Figure 2. Plot showing modeled BMP adoption curve and data points from FarmFLOW BMP Benchmark Surveys

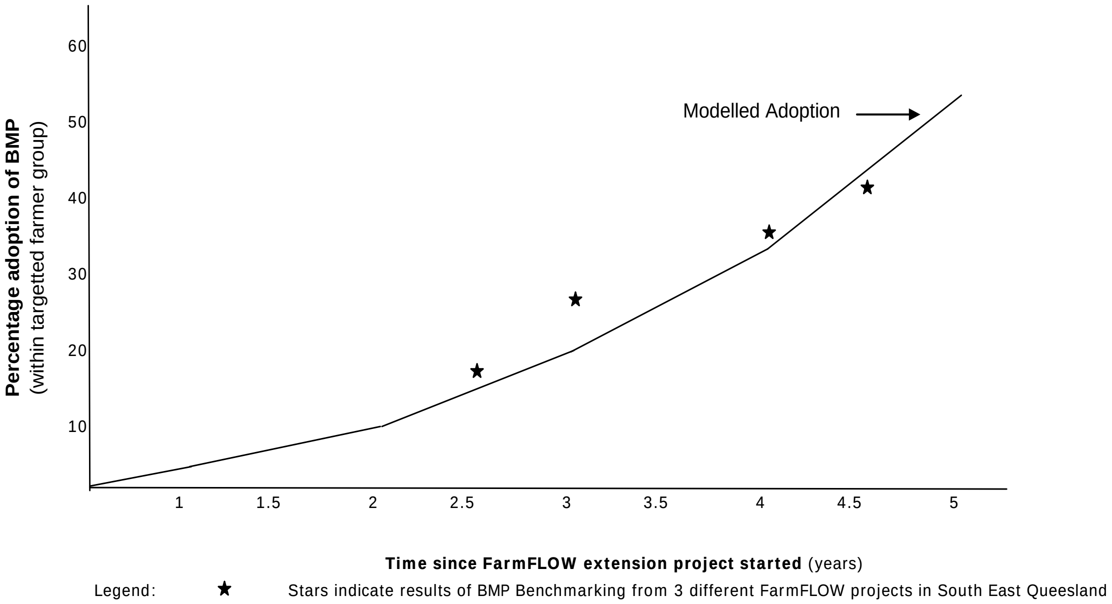


Table 1. Estimated number of farms and adoption benchmarks in 2009

Industry	Class D	Class C	Class B	Class A	Total
Strawberry (surveyed)	15	90	30	15	150
Pineapples (surveyed)	70	50	25	0	145
Cane (estimate)	8	72*		8	88
Total	93	212	55	23	383

* Note: Figure is an estimate of combined Class C & B growers

Table 2. BMP used in the determination of costs and benefits of adoption

Class B Practice	Industry Applied
Mulch in the interrow during establishment of crop	Strawberry Pineapple
Drainage management (reprofiling and armouring)	Strawberry Pineapple
Use of improved nutrient products and application (slow release, targeted)	Strawberry Pineapple
Matching nutrient application to crop need through leaf/ sap analysis or soil analysis	Strawberry Pineapple
Improved soil management (reduced tillage)	Strawberry Pineapple
Reduced fertiliser usage - soybean crop in rotation	Cane
Moving from conventional till to minimum till with GPS guidance *	Cane

* Note: This is a Class A practice

The systems dynamics adoption profile suggests that if the current trends in adoption continue then the target of 80% adoption of target BMPs could be achieved by 2018. The adoption curve is based on a scenario of enhanced region-wide investment for the delivery of the FarmFLOW framework of $672,000 - $866 400 per year from 2011 to 2018. It includes investment in agricultural extension and economics officers ($878,000), conduct of farm trials ($132,000), demonstration farms ($432,000), workshops and training (including Industry Farm Management Systems) ($211,200), BMP adoption incentives ($435,900) and evaluation and monitoring ($244,000). Incentives to date have featured a mix of matching grants and a competitive nutrient and sediment reduction 'tender'.

Variation in farm size may affect the economics of adoption, however, this is not thought to be significant considering the generally small property size in SEQ. Contemporary data from regional producers were used to analyse the economic impact of adopting the above practices across an average sized farm using partial farm budgets developed in collaboration with growers in Phase 1. This showed that adoption of the above BMPs increased the gross margin of strawberry production by $1,453 per ha, pineapples by $646 per ha and cane by $612 per ha.

An estimate of the societal benefit for savings in off-site loss of soil was calculated using Moore and McCarl's (1987) valuation as a base and converting it to cost per tonne of soil lost using the Revised Universal Soil Loss Equation. Using this method the non-market value of costs avoided by adoption of BMP on farms was estimated at $1.98 per tonne (AUD 2010) of soil conserved within the property. Expected reduction in nutrient loss through leaching was estimated from changes to fertiliser regimes. The social value of these savings was estimated as being equivalent to the cost of fertiliser saved. These are considered to be a conservative estimate of benefit as they does not, for example, include the benefit of enhanced commercial and recreational fishing from reduced algal blooms (Savige 2006).

Based on the above assumptions and a discount factor of 6%, implementing the FarmFLOW Area Wide Management Framework at a cost of $4,700,000 from 2011 to 2018 would have an Internal Rate of Return (IRR) 7%) and a Benefit-Cost Ratio (BCR) of 1.4 when only the costs and benefits on farm were considered out to 2026.

The net present value (NPV) was converted to a yearly figure (annualised) as a measure of average annual returns generated over the life of the project (expressed in today's dollars). The analysis showed that without any valuation of societal benefit flowing from the reduced diffused source pollution, the program would have a NPV of $1,030,556 accruing to industry at an average annual return of $101,976.

When the non-market value of benefits are included in the analysis, the expansion of the project to target the three high risk agricultural catchments in SEQ was found to have IRR of 13%. Similarly when the societal benefit flowing from reduced diffused source pollution is included, NPV of the proposed program of activity increases to $5,330,713 at an average annual return of $527,485. When the flow of total benefit is considered the investment in FarmFLOW breaks-even in year 12. The analysis suggests that expanding the FarmFLOW framework to all catchments assessed as having a high level of hazard as a result of nutrients sourced from agriculture driving coastal algal blooms has a BCR of 1.6.

The biophysical impact of farmer adoption of the best management practices summarised in Table 2 is sizeable. The per hectare rate of reductions in off-site flow of sediments and nutrients utilised in the benefit-cost analysis are outlined in Table 3.

Table 3. Estimated Soil and Nutrient Loss from Production

Industry	Average Farm Size	Sediment Loss	Nitrogen Loss	Phosphorus Loss
	(ha)	(tonnes/ha/year)	(kg/ha/year)	(kg/ha/year)
Strawberries	5.0			
Class D/C		44.64	22.32	0.83
Class B		1.49	0.74	0.03
Pineapples	31.03			
Class D/C		69.75	34.88	1.29
Class B		2.23	1.12	0.04
Cane	52.04			
Class D/C		17.86	8.93	0.33
Class B/A		1.19	0.6	0.02

Discussion

The Tietenberg theory suggests that excessive erosion creating sediment loss above the social optimal occurs via excessive production which occurs because farmers do not pay most of the external cost. Profitability is therefore over-stated and leads to production in excess of the optimum. While the actual cost has not been calculated in this study, it was estimated that the difference in cost to the community between non-sustainable farm management practices and adoption of recommended best practices for soil management was in the order of $802,000 per year for the estimated 9,200 hectares of cultivated land in SEQ. This represents an externality cost of $87 per ha of production.

In our study the mix of private and public investment required to move to 80% adoption of best practice did not break even until after year 15 if only the on-farm benefits were included. Social benefit-cost analysis factors in the environmental spill overs from private decisions and in this analysis consideration of off-site societal benefits brought forward the break-even point by three years. This study has supported the argument of Tisdell (1996), who suggested that when societal benefits and costs are considered, more sustainable forms of agriculture tend to have a higher benefit-cost ratios in relation to other practices.

The FarmFLOW framework was designed to actively address profitability, risk reduction and subsidy drivers. Partial farm budgeting demonstrated that the suite of BMPs recommended and analysed in this study all had a marginally positive benefit on farm gross margins ($612-$1,435 per ha) with the need to acquire machinery determining the length of time required to increase the annual profit of the enterprise. Over a decade of active catchment management in SEQ has led to a high level of community awareness in regard to the link between agriculture, diffuse rural pollution and downstream impacts such as coastal algal blooms. In Phase 1 of the FarmFLOW project, engaged farmers were not only made aware of this linkage but also were involved in obtaining and considering real-time local data which clearly demonstrated this link. This, together with an understanding that increased exposure of production to non-farming neighbours in the peri-urban zone increased the potential for the surrounding community to impose ‘a social licence to farm’ through political activity, has resulted in practice adoption as a risk management measure.

The subsidy based driver is implemented within the framework and costed in the analysis through the full funding of trials and demonstration farms which allow ‘early adopter’ farmers to demonstrate the production, economic, environmental and social costs and benefits of change to themselves and their peers ($564,000 budget in CBA). In addition, provision was made for devolved grant and market based instruments (e.g. tender systems) for farmers seeking government assistance for adoption of recommended practices ($435,900 budget in CBA). While this study did not analyse the costs and benefits of a regulatory alternative, it clearly showed that a voluntary extension approach supported by incentives and investment in on-farm trials, demonstration and action learning would have a positive return on the ongoing investment by government (IRR 13.4% and BCR 1.6) generating an average off farm social benefit of $425,509/yr.

Another alternative avenue for government investment is in schemes focussed purely on stream bank erosion. Riparian restoration is frequently posited as an efficient and effective mechanism to achieve reduction in diffuse rural pollution. The results of this study suggest BMP adoption achieves similar BCR and IRR to the average results from Sillar Associates’ (1998) analysis of nine case study dairy and beef enterprises that rehabilitated degraded stream banks in the Mary Valley. Their analysis of on-farm costs and benefits indicated an average IRR of 15.9% and an average BCR of 1.9. However, BMP schemes could be more reliable in the achievement of positive benefits, with 55% of case study riparian restoration farms in that study achieving a BCR of less than 1 and an IRR of 0 or below.

The principles of the FarmFLOW methodology have now been adopted as part of the Education and Extension Strategy for the Reef Water Quality Protection Plan (Stockwell 2010) with a $1.4 million pilot in the Johnstone and Herbert Catchments of North Queensland. The government has invested both in a voluntary extension and incentives approach, and in a regulatory approach in the highest risk catchments and industries. A benefit-cost analysis which compares voluntary and regulatory approaches would provide valuable insight into this ongoing area of economic and rural sociological research. Similarly, future research that compares the efficiency and effectiveness of investments in programs that directly target adoption of BMP with investments in broader programs, such as catchment improvements, re-vegetation, urban stormwater management and wetland protection, is warranted.

Conclusion

The personal, social, cultural and economic 'context' within which farmers operate has a major influence on the success or failure of rural engagement projects targeting rural diffuse pollution. This benefit-cost analysis shows a positive societal benefit flowing from the enhanced adoption of best management practice as a result of continued investment in the FarmFLOW area-wide management extension framework. This framework has been designed to reduce the impediments to adoption by specific extension, agricultural economics, and catchment management techniques which respond to the specific industry and sub-catchment contexts in coastal peri-urban SEQ.

The results of the CBA support the continued investment in an area-wide approach to agricultural catchment management based on an incentivised voluntary framework. An investment in the proposed program of activity over eight years, including agricultural extension and economics officers ($878,000), conduct of farm trials ($132,000), demonstration farms ($432,000), workshops and training (including industry Farm Management Systems) ($211,200), BMP adoption incentives ($435,900) and evaluation and monitoring ($244,000) was shown to have a NPV of $5,330,713 at an average annual return of $527,485 and an internal rate of return of 13% and a BCR of 1.6.

The use of contemporary real world farm data generated in Phase 1 of the FarmFLOW project increases the reliability of the costs and benefits of adoption. The validity of the predicted flow of benefits over time, however, will be reliant on how accurately the Sterman's system dynamics model (2009), used to generate adoption curves, simulates actual BMP uptake as a result of this program. This will require evaluation in the future.

While the benefit-cost analysis includes a conservative estimate of the social benefits of the modelled adoption curve ($425,509 per year), the study shows that increased government investment in the program can be justified on the long-run benefits to industry alone (IRR 7% and BCR 1.4).

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Crisis as an opportunity for change?: A case study of applying resilience thinking to extension responses in dairy industry crisis

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Abstract. This paper outlines a study conducted with a regional extension committee in the dairy industry in Western Victoria, Australia. The aim was to understand experiences of crisis within the region's dairy industry and its current crisis response approaches. It also tested alternative extension approaches through applying resilience thinking and farmer segmentation. The study included interviews, a desk-top development of a resilience framework and a role-play workshop of a mock-crisis situation. The effects of crisis were influenced by the capacity farmers and their farming system developed pre-crisis. Factors affecting the capacity to respond included the farmer's personal and financial context, beliefs and expectations concerning farming itself, past experiences related to the crisis, the extent to which goals were threatened and the need for change. Farmers reported a limited ability to respond during a crisis in ways that mitigated its effects. The introduction of a resilience perspective, demonstrated the need to embed alternative approaches at a pre-crisis planning stage or in improved post-crisis learning events.

Keywords: Resilience thinking, extension design, farmer segmentation, role-play, dairy industry

Introduction

The impact and management of crises in agriculture has been a topic of increased interest within agricultural industries and government. Over the last decade, agricultural industries in Australia have faced multiple challenges such as drought, natural disasters (bushfires, floods), volatile farm-gate product prices, and significant policy change (e.g. Murray-Darling Basin plan). Some agricultural industries and policy groups are increasingly questioning their crisis response strategies. Of particular interest is the extent to which crisis responses are designed to support recovery from crisis, as opposed to more strategic responses focusing on longer-term resilience. A great deal of research in recent years has explored elements of these issues, particularly in the context of drought. For instance, explorations of the experience of drought as crisis (e.g. McGuckian and Rickards 2011) and the call for reframing of drought policy away from "crisis" to "risk" management (e.g. Botterill and Wilhite 2005). Further, the need for radical changes and transformation in agricultural industries in the context of climate change are surfacing (e.g. Beilin et al. 2012). Largely unexplored in this burgeoning field is an understanding of crisis and crisis response within agricultural industries themselves, and in contexts outside of drought. Along with this, the options open to extension for supporting change rather than bounce-back or recovery from immediate crisis have also lacked investigation. Developing knowledge in these areas will assist in the formation of extension strategies for both the public and industry sectors with respect to their crisis management.

This paper progresses knowledge in these areas by drawing on results of a study conducted with a regional extension committee in the dairy industry in Western Victoria, Australia. The aim was to understand experiences of crisis within the region's dairy industry and their current approaches to crisis response. The study also tested the potential for alternative approaches in crisis response through applying resilience thinking and attitudinal segmentation to their extension design. Key concepts informing the study are outlined including: the definition of crisis; defining resilience and the contribution of resilience theory to crisis response; attitudinal segmentation and its application in responding to crisis; and extension and its role in crisis response.

Defining crisis in agricultural industries

Crisis is defined differently in fields as diverse as health, economics, the environment, disaster management, war and conflict and organisational communication. For the purposes of this paper, and in light of our interest in the role of extension in agricultural industry crisis, we draw from communication studies to define crisis as an unstable or dangerous situation that usually involves abrupt change, and has the characteristics of uncertainty, unexpectedness, threat to important goals and requiring a need for change (Seeger et al. 1998).

We distinguish this definition from the important field of emergency management or emergency response in which recovery from damage and return to a pre-event state is the primary focus. In this paper, our interest in crisis events is on vulnerabilities and opportunities that such events pose for farmers and their industries, and what change extension can support to minimise impacts of future events. Some examples of agricultural industry crisis include unexpected commodity price slumps, disease outbreaks and product quality problems. We also consider crisis to be socially constructed whereby the individuals or social groups themselves consider a situation or an event as a crisis. We recognise that crisis is created in the discourse of and negotiations among people as social actors (Berger and Luckmann 1967). Therefore, although a slump in commodity prices may be a crisis event shared by a group of farmers in the same market, the experience of this as crisis will differ.

Defining resilience and the contribution of resilience theory to crisis response

In the field of ecology, resilience has been defined as the "capacity of a system to absorb disturbance and still retain its basic function and structure" (Holling 1973, p14). The interactive dynamics between social and ecological systems have more recently been represented in concepts of social-ecological systems (SES) (Walker and Salt 2006). The central features or concepts of SES are: continuous adaptive cycles (exploitation, conservation, release and reorganisation) (Walker and Salt 2006); the organisation and interrelationship between systems-within-systems or nested systems (panarchy) (Holling 2001); basins and thresholds in and between systems (Folke et al. 2010); and the influences of adaptive management across scales. Resilience management has twin aims of preventing the system from moving to undesired system configurations in the face of external stresses and disturbances; and nurturing and preserving the elements that enable the system to renew and reorganise itself following a massive change (Walker et al. 2002).

Incremental adaptation in response to crises can lead to systems becoming locked in to trajectories that are, in the long term, unsustainable (Anderies et al. 2006). In dealing with crises, there is therefore an ongoing tension between the need to protect and develop the current agricultural industry configuration, and the need for transformation and change in a changing environment. Applying resilience thinking to the challenges for agricultural industries includes the extent to which there is systematic consideration in building the resilience of the industry in the long term; recognition of the resilience implications of current industry trajectories and retain (or develop) the capacity to reorganise when necessary; and crisis response consistent with both short- and long-term and multi-scale resilience.

These concepts are considered by the authors to have particular strengths for the situation of crisis response in agricultural industries, particularly in considering the scope of available response options (Cote and Nightingale 2012). Resilience, as it is understood through SES, is not without criticism. Some authors believe SES does not adequately address political economic factors in conceptualising vulnerability (Folke et al. 2010). However, resilience thinking may offer a framework or heuristic for people in crisis response roles to consider alternative response options based on understanding the importance of system dynamics. Resilience thinking means expanding the number of elements considered in decision-making, and forward planning in farming or in industry services to enhance options available, and therefore, resilience (Love et al. 2008; Anderies, et al. 2006) . In the approach outlined in this study, we draw on what Cote and Nightingale (2012) define as "a situated resilience approach" which prioritises local knowledge and situations, and empirical studies of SES dynamics.

Understanding diversity in experience of crisis amongst farmers and service providers

That people experience crisis differently is an important issue for crisis interventions to address. Although much research has focused on documenting and analysing the experience of crisis, the main issue for crisis response is what to do about these diverse experiences of crisis and the different ways crisis may be perceived. For extension teams in crisis response, is there a way to pre-empt or understand diversity in response to crisis amongst a farmer population? Drawing on the definition of crisis used in this paper and resilience thinking ideas, crisis can be considered as any event or situation that challenges important goals and through so doing, creates a level of anxiety or concern for the implications of such changes. Within agricultural industries this would include the goals of farmers. Crisis could be perceived differently depending on farmers attitudes towards their farming (i.e. as a business, as a pathway for the entry of new generations). Understanding diversity of attitudes and beliefs of farming amongst a farming population could offer extension an entry point for considering the impact of crisis and also potential different responses to crisis that would aid in extension design. Previous studies of the diversity of farmers worldviews and attitudes toward farming in the dairy industry had concluded this understanding as being important for extension design (e.g. Nettle and Lamb 2010; Waters et al. 2009). Could an understanding of different segments of farmers, with respect to attitudes towards their farming, assist crisis response design?

The role of extension in crisis response

Extension is broadly defined as the process of enabling change in individuals, communities and industries involved in the primary industry sector and with natural resource management (SELN 2006). *Enabling change* signals a broader role for extension beyond "extending knowledge and information". Extension and advisory services (both public and private) are resources drawn on in times of agricultural industry crisis and shocks and are considered to play a critical role in helping farming families make decisions, particularly the complex decisions about future plans in a changing environment (McGuckian and Rickards 2011). Some authors suggest this role is increasing as extension moves from situations requiring information delivery to situations involving value-based conflict (Nettle and Lamb 2006) requiring roles in community facilitation (Cartwright et al. 2002), or representing farm change to policy (Nettle and Paine 2009).

In this paper, the role of extension in crisis response for resilience is of particular interest and an important area for extension policy. Could resilience thinking and attitudinal segmentation assist in developing different extension responses to industry crisis that support adaptation beyond recovery and bounce-back? In order to answer this question and progress a "situated resilience approach" (Cote and Nightingale 2012), a research design was proposed in conjunction with an agricultural industry regional extension and education committee (Western Victorian dairy industry regional extension committee or the SW-REC). The following research questions were established:

- How is crisis defined and experienced by people in the dairy industry in Western Victoria?
- What are the routines of crisis response in the region?
- Is it possible to alter crisis response routines using resilience thinking and if so, are there potential benefits?
- How could extension providers support different routines in crisis preparation, crisis response and post-crisis learning?

The next section provides the context in which the study was conducted and details the methods used.

The dairy sector in Western Victoria and crisis events

The Australian dairy industry is the third largest agricultural industry in Australia and generates A$3 billion in pre-farm gate income, ranking third in world dairy trade. The state of Victoria, Australia's principal dairying state, accounts for nearly 60% of Australia's total dairy production, has an annual turnover of A$5,125 million and produces over two-thirds of the nation's fresh milk and cheese (Dairy Australia 2011). Western Victoria is the largest milk producing region in Australia with around 24% of total national milk supply. There are approximately 1,700 dairy farming enterprises producing a total of about 2.4 billion litres of milk annually. The average herd size in the region is larger than the rest of Australia at 312 cows (298 ave) with an average output of 2.3 million litres of milk per farm year. The industry directly employs about 3,955 people on dairy farms and an additional 3,240 people in the processing sector, representing 10% of all employment in the region (Dairy Australia 2011). WestVic Dairy estimates that the current value of the dairy industry to the region is about A$4.6 billion.

Crisis events have affected the dairy industry at different scales in recent times. In late 2009, a crisis in dairy production confidence emerged from ongoing drought, failed spring seasons and in particular, an unexpected collapse in milk prices as a flow-on effect of the global financial crisis. This presented a challenge for the dairy industry in how to effectively respond and support farmers. Farmers were affected differently; some experienced little disturbance while others struggled and in some cases needed to leave their farm businesses. At this time, it was increasingly apparent that over recent years, a large proportion of industry and extension resources had been directed toward responding to immediate crisis rather than setting and implementing longer-term strategies. Further, at the farm or regional scale, there had been limited forward planning for crisis and little structured learning from crisis.

Method

In order to address the research questions, the project team required methods that provided an opportunity to work in a current context of extension responses and collect data about the experience and reflections of crisis and crisis response. Further, it was necessary to work with extension team themselves on considering alternatives to crisis response practice. The methods chosen reflected a cooperative or appreciative inquiry (Heron and Reason, 2006). The study was conducted between March 2010 and June 2011, and involved three overlapping phases including:

4. Interviews with farmers (n=8) and extension officers (n=4) about their experience of industry crisis. A theoretical rather than representative sampling approach was applied (Mitchell 1983) to provide a range of potential responses to crisis (farm interviews) and years of experience (extension interviews). Farmers interviewed included farms at different stages of the business cycle and a range of farming styles. Farmers completed an attitudinal profile to identify differences in farming worldviews (see Waters et al. 2009). Interviews covered questions concerning their experience of crisis and managing crisis, current crisis preparedness, and key learning's and changes as a response to their experience. Extension people interviewed were chosen to include a range in extension roles (technical specialist or industry development) and years of experience (two years to 21 years extension experience). Interviews were recorded and thematic analysis used to identify common themes that contributed toward understanding diversity of crisis response in farming and extension (Research question 1 and 2).
5. Development of a resilience framework for preparing and responding to crisis drawing on the resilience literature and previous empirical work in the dairy sector (Love et al. 2008). Also, results from attitudinal segmentation of dairy farmers conducted in 2008 were reviewed to consider potential population-level differences in crisis responses (see Waters et al. 2009). This provided a framework for use with the SW-REC (Research question 3).
6. Testing and further development of the framework in a role play of crisis response with the SW-REC and invited stakeholders (n=11) to explore the diversity of responses to a crisis and an examination of alternative response options that could contribute to resilience.

The role-play scenario was designed to allow reflection on routines of crisis response by the people involved (Research questions 3 and 4). Although scenario-planning methods are commonly used to enable divergent thinking about future issues and states (Miller and Cardinal 1994), they are not a particularly strong method for uncovering root problems within current ways of responding. The role play method also allowed for practising crisis response in a safe environment and reflection on this practice through considering the strengths and weaknesses of the practice as an alternative approach to crisis response (e.g. Greenberg and Eskew 1993). The technique was agreed with the input of the leadership group of SW-REC who then acted as key recruiters for the role-play exercise.

The role-play design

To conduct the role play, an artificial crisis was developed and a response role-played by the SW-REC. The scenario developed aimed to present a significant threat to current dairy systems, one which was unexpected and presented significant challenges to existing farm management. The example used was a fictitious cereal ergot infestation that reduced the milk producing potential of infected cereal and possibly decrease cow reproductive performance. A half-day role-play workshop was developed by the project team to include: a) an experience that provided people with a role to play in crisis response close to their current role; b) the application of the resilience and segmentation framework to help in enacting this role; c) enough time for doing and deciding "in-role"; and d) enough time for reflection "out-of-role". Role play participants included farmers, departmental research and extension representatives and near farm professionals (consultants and a vet).

Roles chosen for the workshop included: people acting as themselves (e.g. farmers, extension officers) and a small number of fictitious roles not represented by the current members, including a milk factory representative and a farmer asked to take on a very conservative and pessimistic role. The workshop process was:

1. All participants received a media release on the crisis a week before the workshop and were allocated roles. This allowed some time to consider the implications of the crisis to their situation.
2. At the start of the workshop, each participant talked about a crisis they had faced and how they had responded.
3. The "ergot crisis" was introduced.
4. The group was asked to come up with a response to the crisis from the SW-REC without any guidance. (This was used as a proxy for describing current crisis responses in this context.)
5. The group was then given the resilience framework for crisis response (see Figure 1) to use as a guide. Further, the dairy farmer attitudinal segmentation results (see Waters et

al. 2009) were provided to the group (Table 1) and they were asked to reflect on how this might inform or change their response.

6. During the workshop a sign was used to indicate when role play was "in progress" or not.
7. The local dairy extension team from the Department of Primary industry Victoria (DPIV) presented a standard crisis response program, and the SW-REC group was asked to critique and modify this plan.
8. The workshop finished with a time of reflection, identifying what worked well and what could be improved, as well as reflecting on the group function during the workshop.

The unit of analysis for the entire study was the extension crisis response group. The overall findings of the study were presented to DPIV and other agricultural industry extension staff to consider the applicability of findings to other contexts. The findings from this step are presented in a project report (Love et al. 2010) but are outside the scope of this paper. The next section outlines the findings from study presented against the research questions.

Figure 1. Summary of a resilience framework developed to assist extension response teams

Resilience concept (from Walker and Salt 2006 and Love et al. 2008)	**Application to extension team response in crisis: questions for extension to consider**
Situation analysis: What's the nature of the crisis?	What are the emerging responses to crisis (radical/conservative)? Which groups of farmers would perceive this situation as crisis? What are the key scales that you will focus on for this crisis? Who are you developing the response for (i.e. what scales?)? What is the timeframe of the crisis?
Adaptive cycle analysis: To what extent will the crisis create opportunities for reorganisation?	Where are the majority of farm businesses "at" in the adaptive cycle (exploitation, conservation, release and reorganisation)? What are your strengths in the current system to respond? What opportunities are there to change or reorganise the system (internal control and adaptive capacity)? Are there particular vulnerabilities because of this?
Possible futures Decide on appropriate scale of action and focus for action What is the most relevant boundary of the system? What are the most important values to conserve?	What options or ideas for crisis response emerge (other than information provision)? What is the purpose of our crisis response (e.g. preserve farmers in their current farming systems)? In the longer term, will the purpose of our response create vulnerability? What is the most relevant scale for our action (e.g. individual person, dairy herds, farm businesses, dairy company, community) across both social and biophysical scales? What is the boundary for our response (particular groups of farmers, a geographic location)? What are the cross linkages that need to be considered or drawn upon? (e.g. farmer-farmer networks, dairy company arrangements)?
Human system aspects	Who can be mobilised to respond? Existing networks in this challenge. Communication and technology resources
Implications of each trajectory and resource allocation – monitor change and progress	Prioritise time and resources based on trajectory Evaluate emergent properties of the crisis: e.g. scale of impacts. Is the crisis response accounting for the diversity of responses? Is communication reaching the right people? Are perceptions of the crisis changing? Are limits being "hit"? Are conversations being fostered about these limits (e.g. on a farm, the possibility of leaving farming; or the potential for dairy industry to decline significantly within a region)?
Has adaptive capacity been built?	Are we in a different position on the adaptive cycle? Have the values to be preserved changed? What scales have emerged as being important and to whom?

Table 1. An overview of potential diversity of crisis response amongst dairy farmers based on a segmentation analysis of the dairy farming population (%) with respect to attitudes towards farming (for a full explanation of the segmentation method and characteristics of each segment, see Waters et al. 2009)

The dairy farmer segments (Waters et al. 2009)	Segment 1 Family first (5.5 %)	Segment 2 Winding down (3.6 %)	Segment 3 Love farming (17 %)	Segment 4 Establish-ed and stable (25 %)	Segment 5 Open to change (22 %)	Segment 6 Growing for the kids (27 %)
Segment character-istics pertinent to crisis response	Could be considered resilient to shocks due to financial reserves Unlikely to be involved in industry crisis responses Some shocks may threaten sustain-ability	Shocks may prompt exits if timing right Unlikely to change farming practices during crisis This group would "fly under the radar" of industry response Some shocks may threaten key goals	Confident in current system to "bounce back" from shocks More likely to "fine tune" than change More likely to attend groups/ industry workshops and therefore a key entry point for supporting change.	Self-reliance and in-dependence means this group hard to reach in a crisis Potential to be exposed to shocks as they are less likely to consider different or "outside the box" options	More interested in profit impacts of shock than other groups Open to new ideas and change More likely to use advisers and consultants If new ideas are important – this group should be engaged in crisis response	Would be concerned about the impact of shocks on next generation Depending on the shock, it may delay succession Change may be needed to maintain goals

Adapted from Waters et al. 2009. The dairy farming sample is a random survey of 450 farms and cross-referenced to situational, demographic and behavioural indicators.

Results

Research question 1: How is crisis defined and experienced by people in the dairy industry in Western Victoria?

Farmers indicated they had experienced two different "shocks" or events in recent times (2006/2010), the milk price drop of late 2008 and the failed spring or late spring break of 2006/2007. Farmers perceived these events differently; each event was experienced as a crisis for some and not for others. The main reasons for the diversity of experience of crisis were clustered into themes and summarised:

The nature of the crisis event influenced which farmers were likely to be more affected. The milk price drop affected farmers who were more vulnerable to income variability, such as those without cash reserves and with relatively high levels of fixed costs. One farmer (600 cow herd) mentioned that he had pre-purchased feed inputs at a fixed cost as a risk management strategy to insulate the farm against rising costs, but this had back-fired in the crisis. Poor seasons, such as the failed spring, had less impact on those with extensive feed reserves (irrigation and silage), and hit harder for those who were already experiencing high levels of stress from other events on their farms.

***The business goals and strategies of farmers can create vulnerability to particular crisis events*.** A young farmer who suffered during the milk price drop commented: "If you're running your business as efficiently as possible, there shouldn't be anything left to cut". In another situation, a farmer had turned the failed spring into an opportunity by investing in a lucerne growing property which then provided enough hay for his farm, and to sell in a time of high demand.

***Life stage, personal circumstances and beliefs also amplified the effects of a crisis event*.** Older farmers who experienced the milk price drop as a crisis commented that they felt particularly stressed because they did not believe that at their stage of life this sort of stress would arise again.

> "I was stressed, because I've been there before, and I was thinking 'How did I get into this position again?' I felt like I couldn't do much and if you can't do much, you're annoyed.
>
> "I went into a state of depression, and last year's been personally my worst, I thought that we had the score on the board. A lifetime's work was just about fulfilled."

By contrast, a younger farmer for whom this was a new experience, felt excited at having handled the crisis as well as he did. Of the farmers who experienced the failed spring as a crisis, one had a family crisis, with her husband seriously injured, and another was in a "development" phase of increasing property size and milk herd numbers while simultaneously building a new house.

***Previous experience of crisis appeared to have been critical in preparing farmers*.** Of the farmers interviewed, most did not experience the failed spring in 2006/2007 as a crisis. Previous variability in seasons gave these farmers experience which shaped the way they managed their farms prior to the 2006/2007 event. Their prior experience had equipped them with both an expanded sense of what was possible, as well as skills for managing feed in a tough season. Other farmers described the strategies they adopted prior to 2006/2007 as intentionally "drought-proofing" themselves. In this regard, the timeframe for crisis situations was important, with events being defined as crisis at different times.

Those who had *not* experienced the events of the milk price drop and/or the failed spring as crises had strategies in place that helped mitigate negative effects. It was observed that mitigating strategies were not always intentional or carefully planned

In summary, the affects of crisis were very much influenced by the capacity farmers had to respond at the time the crisis occurred. A farmer's personal and financial context and beliefs along with their past experiences mediated the impact of the unexpected situation, the extent to which goals were threatened and the need for change.

Research question 2: What are the routines of crisis response in the region?

The dairy industry has tended to support farmers in industry crisis in three main ways:

1. Providing support to short-term farm management decisions in the context of the crisis (e.g. cash-flow budgeting, debt strategies, feed alternatives, sign-posting to government support).
2. Communicating clear and consistent messages about the operating environment to farmers and service providers (e.g. changes in input availability and prices such as weekly hay and grain reports), shifts in global demand for dairy products such as DairyLive regional broadcasts, Industry Situation and Outlook sessions (Dairy Australia 2011). This has the dual aim of reducing the likelihood of conflicting information circulating and to convey the collective response and acknowledgment of the situation as widely as possible.
3. Ensuring dairy industry organisations work together to ensure consistent and widely understood information (e.g. cross-organisation working groups, delivery of 1:1 information and advice).

These strategies have been largely effective in ensuring farmers have the best available information and support to their dairy business operations.

In interviews, farmers reported a limited ability to respond during a crisis in ways that mitigated its effects. Generally, either farmers had mitigating strategies in place prior to the crisis, or they continued doing what they could to maintain their business with what they had. In each case, there was a sense that the farmers felt very close to failing but continued because of a faith in a better future. One farmer indicated that he had consciously chosen his response when he spoke of making a commitment to himself when the milk price drop took effect, that if he was going to go down; he was going to go down trying. Others generally saw their response as the only one they had available, giving the sense that they felt locked in to particular actions.

With respect to seeking help in responding to crisis, farmers sought information and advice from the range of advisors, consultants and networks in which they were already involved. Milk factory consultants, other consultants, accountants, banks and discussion groups were mentioned as primary sources of support or advice. Some had talked to friends and neighbours, finding this reassuring, while others actively avoided talking about bad times. Some noted that their position in their community as "better off" prevented them from being able to discuss their situation openly. Some farmers had found information days and farmer meetings helpful in gauging the crisis and gathering information without explicitly asking for help.

Extension officers also provided insight into their observations of common routines of crisis response in their region. On one hand they identified that not all farmers wanted support from the industry and did not associate strongly with the dairy community nor see it as a source of support during difficult times. In addition, the wider media often focus on the sensational and the negative in the midst of crisis. Extension staff considered a key part of their role in crisis situations was in balancing such messages. Forms of decision paralysis and social isolation on the part of farmers were also observed. Extension staff were often contacted by farmers concerned about their neighbours or by farm input supply company representatives who were concerned about their lack of social contact. Extension staff mentioned a number of famers were reacting to needs on a daily basis, such as not ordering feed until it had run out or, more commonly, working harder and longer to cope.

Research question 3: Is it possible to alter crisis response routines using resilience theories and if so, are there potential benefits?

As part of the study, a resilience framework for preparing and responding to crisis was developed drawing on the resilience literature and previous empirical work in the dairy sector (Love et al. 2008). This framework is summarised in Figure 1.

Results from attitudinal segmentation of dairy farmers conducted in 2008 were reviewed to consider potential population-level differences in crisis responses based on differences in farmers beliefs and attitudes to farming (i.e. their farming “worldview”) (see Waters et al. 2009; Nettle and Lamb 2010). Table 1 provides a summary of the diversity of world views of Australian dairy farmers and pertinent differences in potential responses to crisis. In particular, the segments reflect diversity in four main areas that were found to be important in understanding diversity in the experience of crisis in the interviews. These include: a) farmers perceptions of risk (see O’Kane et al. 2010); b) farmers motivations for farming (i.e. for some segments, change that threatens the long-term viability of the dairy industry and the ability of their family to take over the farm may be more important than change which affects the short-term profitability of the farm; c) the extent to which dairying is an important lifestyle (e.g. 76 % of dairy farmers do not have any plans to leave the dairy industry, and would choose to stay and adapt if possible rather than leave as a response to a crisis); and d) interest in innovation and change (i.e. there are segments that prefer to leave the trialling of new ideas to others). Therefore, some crisis preparation and resources may be best directed to segments that are more open to trialling new ideas in order to identify possible alternative opportunities).

These frameworks were tested and further developed in the role play of crisis response with the SW-REC. The role-play workshop proved powerful for revealing established routines of crisis response amongst local groups. Quite early in the role-play exercise, the group decided they needed more information before they could work on a response and this issue remained for the entire role play. The dependence on more information before making plans or acting proved to be the key constraint to acting differently and applying the frameworks. The uncertainty crisis situations create and the need to rapidly accumulate information about the crisis to inform action was an important learning. However, striking a balance between acting in the light of inadequate information and accumulating information proved difficult. However, the frameworks provided the role-play members with some indication of information they may need to source alongside technical information about the crisis.

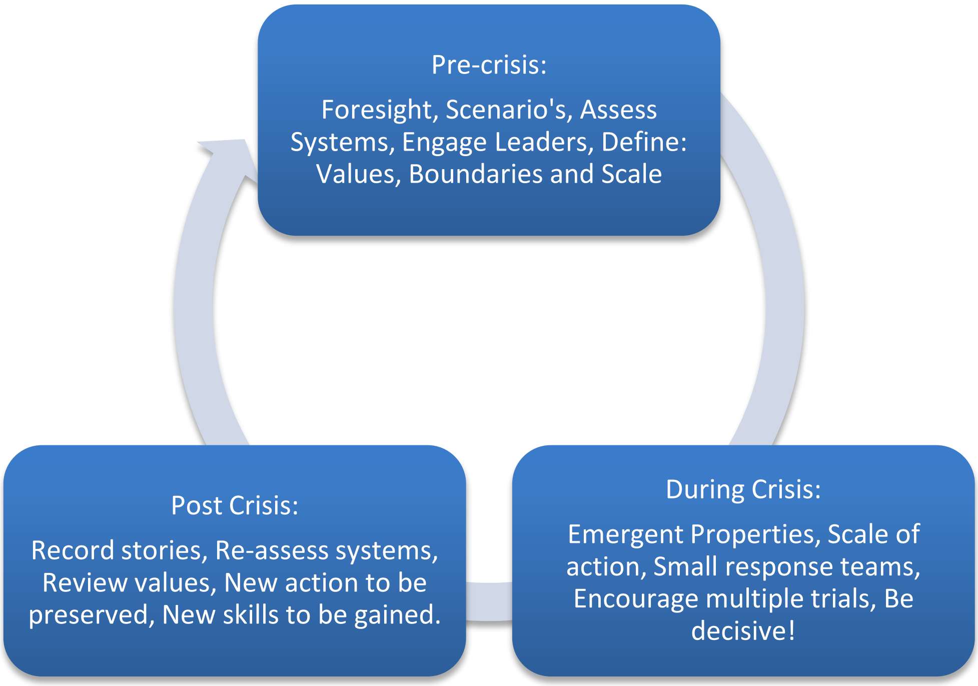
After a briefing on use of the “resilience response tools” prior to the role-play, the group did not draw on the tools to any extent in deciding their new crisis response strategy. The session was run again, with one of the project team acting as an independent facilitator, and this prompted different decisions particularly regarding crisis message content, types of communication and roles for the crisis response team to operate at different scales. It was suggested at the end of the workshop that a skilled facilitator would be useful for taking the group through the steps of responding to a crisis.

Research question 4: How could extension providers support different routines in crisis preparation, crisis response and post-crisis learning?

The focus of the role-play workshop was on activities to undertake during a crisis. On reflection, it emerged that more effective action can be taken before a crisis, in areas of prevention and preparation. In the interviews with extension officers, participants were asked to comment on the extent to which concepts from resilience theory resonated with their lived experience in crisis. Of particular interest were the assumptions of the precariousness of farming systems. Extension officers described the features of “highly optimised systems” that made them more susceptible to shocks as those with reduced system flexibility, high debt levels and exposure to more market variability (through bought-in feeds). However, they also provided some counter evidence of characteristics that they believed helped these farmers manage crisis situations. Even though the systems were less flexible, the people managing them had more adaptive capacity and were more willing to try new things. They also tended to plan ahead better and were more willing to make decisions earlier. This does not mean that highly optimised systems are more resilient, rather, that when faced with less options farm managers did more with what they had. It could be argued that these managers would be even more resilient with less precarious systems. An awareness and acknowledgment of system precariousness by the extension community would help both researchers and farmers make informed decisions about current and proposed system vulnerability to shocks. As a significant link between the research and farming communities, extension has the opportunity to provide critical thinking in systems development.

In response to results from the role play workshop and interviews with extension, the frameworks developed to support application of resilience thinking to extension responses in industry crisis were adapted to assist in building pre-crisis capacity and support post-crisis learning. This is represented in Figure 2. **Pre-crisis capacity** is focused on developing the knowledge of vulnerabilities of farm systems, the networks and resources across different scales that can be drawn upon in times of crisis. **Crisis response** is focused on adapting established routines toward longer term resilience, such as considering the formation and characteristics of a response team, intelligence gathering about the crisis to recognise potential "tipping points" early, acknowledge radical versus conservative trajectories and consider implications for crisis response rather than promoting or favouring a particular trajectory. **Post-crisis learning** concerns the encouragement of debriefing processes, which should be intentional about capturing learning's from the crisis situation.

Figure2. A summary resilience framework for crisis response developed from the study



Discussion

Farmers experienced crisis differently depending on a range of personal, situational and temporal factors. The study suggests that the diversity in farmers' experience of crisis was influenced by the nature of the crisis event or situation itself (e.g. whether it is a natural event or economic situation). Therefore, in crisis response it is important not to assume all crises are the same and a response to one type of crisis can be replicated for another. A detailed understanding of the nature of the crisis and how it may be changing over time will be important. Secondly, the particular business goals and strategies of farmers were seen to expose some farmers to being more vulnerable to particular crisis situations than other farmers. Rather than predicting the vulnerabilities of strategies to particular crisis, extension requires a good understanding of the range of goals and business strategies within an industry/farming population at any time. This knowledge could be drawn upon in considering the impact of crisis across a population of farms. The attitudinal segmentation (Waters et al. 2009) tested in this study is an example of such a population-level understanding particularly related to different goals in farming. Thirdly, it was found different life-stage and personal circumstances affected the experience of crisis. Although this area may be considered to be a potentially large source of diversity that cannot be meaningfully addressed through extension, a consideration of these as factors could assist in the formation of useful partnerships (e.g. if young farmers are considered to be more vulnerable in particular crises, extension could draw upon young farmer social networks in their responses). Fourthly, previous experience of crisis was found to be important in mitigating impacts of crisis events. Farmers with experience of previous crisis can be a knowledge resource for extension to draw on in considering suitable technical advice, or if there is limited experience of similar crisis in a region, this may help build a case for additional resources to support learning. Finally, the time frame of crisis and the potential for crisis events to become prolonged suggests a need for extension to have a “watching brief” on how crisis events are changing and how on-farm responses to crisis are changing.

The findings regarding the application of resilience theories and attitudinal segmentation for supporting change in extension responses to crisis suggest there are a number of challenges to overcome. The strong reliance on detailed information about a crisis before acting and the influence of the people who make up a crisis management team (i.e. their own favoured responses and stage of their own business cycle) were two critical issues. The make-up of response teams is important in that teams require members who are action-oriented in ambiguous and uncertain situations. Facilitation in crisis response was also shown to be influential for considering different or a wider range of response options. For this reason, expanding the awareness of resilience frameworks amongst extension teams and developing facilitation skills in guiding alternative response options is necessary to progress resilience outcomes.

Changing the outcomes from crisis toward resilience was shown to begin with changes to the type of thinking and planning that occurred before crisis response. This “pre-crisis” phase is where there is the greatest opportunity to commit resources to different options, and to develop resilience for future crises. However, it was also recognised that there is not always the opportunity for planning and preparation – crisis, after all, is mostly unexpected. Further, “post-crisis learning” is a critical opportunity for improving crisis preparation but is often ignored in the haste to “move on” from crisis, or not done as well as it could be.

In working as part of this study, the extension team were seeking alternative options from constantly responding to crisis events with the same process of information delivery and a one-size-fits-all approach. In considering the applicability of resilience thinking and applying results from farmer segmentation, the team developed more nuanced understanding of the underlying reasons for diverse experiences of crisis and therefore the need for more nuanced approaches to extension response. This has important implications for extension policy and investment in crisis preparation. The potential application of resilience thinking and farmer segmentation to build adaptive capacity should therefore be further investigated.

Conclusions

The study outlined in this paper aimed to progress understanding of crisis and crisis response within an agricultural industry, and the options open to extension for supporting change rather than bounce-back or recovery from immediate crisis (resilience). The potential for alternative approaches in crisis response were tested through applying resilience thinking and attitudinal segmentation to extension design using a role-play technique. In applying these frameworks, an extension team considered different system boundaries in their response (e.g. the family farm, or the regional agricultural industry?) and which system functions need to be retained through the challenge of crisis (e.g. agricultural production, employment or family wellbeing?) and considered what constitutes an “undesirable” system configuration (and for whom).

In addition, considering the different responses of farmers to crisis by drawing on population level understanding of diversity in attitudes toward farming provided insight into potential different target audiences in crisis response. The study concluded that changing the outcomes from crisis towards resilience began with changes to the type of thinking and planning that occurs before crisis response, and through effective post-crisis learning that can establish new routines for future crises.

Given the public investment in crisis response and management, and the stakes for agricultural industries, extension teams are central participants, operating as a key connect between industry, broader government services and communities. As increasing volatility and uncertainty in market and policy conditions appears to be a new normal for primary industries, having regional mechanisms that support adaptation and responsiveness in coping with uncertainty is necessary for configuring new routines. Situated resilience approaches (Cote and Nightingale, 2012), such as that tested in this research appear to hold promise as such a mechanism, particularly through active engagement with crisis response teams applying action research methodologies. Further research and development is warranted in particular in the intersect between local and industry-wide responses.

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