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Farming looks mighty easy when your plough is a pencil  
and you're a thousand miles from the corn field

**Dwight D. Eisenhower**

# **Eco-n Adoption Patterns and Strategies of South Island dairy farmers**

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**A dissertation submitted in partial fulfilment  
of the requirements for the degree of  
Master of Applied Science**

**At**

**Lincoln University**

**By**

**Daniel E. Smith**

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**Lincoln University**

**2011**

## **Eco-n adoption patterns and strategies of South Island dairy farmers**

By Daniel E. Smith

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The most common form of pollution from New Zealand dairy farming is nitrogen, in the form of nitrates, being leached into aquifers and waterways resulting in increased nitrate levels and eutrophication of water bodies. The nitrate pollutants originate from cow urine and chemical nitrogen fertilisers which both contain ammonium nitrogen. The ammonium nitrogen is subsequently transformed into nitrates and nitrites by microbial behaviour in the soil profile. The transformation of nitrogen by soil microbes is called nitrification.

In an attempt to reduce the negative environmental impact of New Zealand dairy production the nitrification inhibitor product eco-n™ was developed by scientists at Lincoln University and commercially released by the Ravensdown Fertiliser Cooperative in 2004.

Despite the benefits of eco-n™ in both an environmental protection and a production sense there has been lower uptake of eco-n™ than expected by Ravensdown. The usage rate of eco-n™ by Ravensdown's dairy farmer shareholders across Canterbury, Otago and Southland was 17% in 2008 and 7% in 2009.

This research seeks to investigate the factors influencing these eco-n™ adoption rates while also paying attention to published material about the diffusion and adoption of innovations.

The research involved two separate research processes; the first was a quantitative analysis of the Ravensdown dairy customer database to identify the usage patterns of eco-n™. The second stage of the research was a mixed method approach that involved interviewing 108 dairy farmers about eco-n™. The resultant information created a qualitative case study that was then analysed using Microsoft Excel™ as well as more sophisticated statistical computer software.

There were three obvious patterns to emerge from the usage analysis. The first pattern showed a decrease in eco-n™ usage between 2008 and 2009 across all sub-groups. The second pattern showed a consistently higher eco-n™ usage with large farms classified by Ravensdown as Key

Accounts. The third pattern demonstrated a higher eco-n™ usage rate with farms located closest to and within Canterbury.

The second stage of the research project found a range of mediums have helped the spread of eco-n™ information. The two most prominent influences of eco-n™ use have been the Ravensdown Account Managers and other dairy farmers.

The 2009-Users of eco-n™ are more likely to have adopted the technology for its environmental benefits while the discontinuous users are more likely to have adopted eco-n™ for its potential production and economic benefits.

It is evident that the restricted uptake of eco-n™ is a result of inconsistent research messages relating to eco-n™, the limited ability to quantify the on-farm benefits and the variability in the results of eco-n™ use experienced by those who have used the product.

Cashflow and price were also given as reasons for restricted uptake of eco-n™ and there is a distinct relationship between 2008 to 2009 eco-n™ usage and the 2008 to 2009 Fonterra payout price. The application restrictions on eco-n™, the up-front costs involved and the lack of site-specific trial results are other factors adding to the restricted use of the technology.

Over 95% of the interviewed farmers believe they have received enough information about eco-n™ to make a sound use decision.

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# Terms and abbreviations

<b>2009-Users</b>	Farmers who used eco-n™ in 2009
<b>Churners</b>	Farmers who used eco-n™ at some point between 2004 - 2008, but not in 2009
<b>Non-users</b>	Farmers who have never used eco-n™
<b>Account Managers</b>	Ravensdown staff who build and maintain relationships with farmers
<b>Standard Accounts</b>	Ravensdown shareholders who use less than 425 tonne of fertiliser annually
<b>Key Accounts</b>	Ravensdown shareholders who use more than 425 tonne of fertiliser annually
<b>Pugged Soil</b>	Soil structurally damaged by cows' hooves, typically a result of excess moisture
<b>Dry Matter (DM)</b>	The 'fresh' (green) weight of forage such as pasture <i>less</i> the water or moisture
<b>Milksolids (MS)</b>	The valued solid components in milk – at present, milk fat and protein
<b>Stratification</b>	Dividing a group of individuals into smaller sub-groups with common characteristics
<b>N<sub>2</sub>O</b>	Nitrous Oxide
<b>NO<sub>3</sub><sup>-</sup></b>	Nitrate
<b>NH<sub>4</sub><sup>+</sup></b>	Ammonium
<b>N,P,K,S</b>	Nitrogen, Phosphorous, Potassium, Sulphur
<b>Leaching</b>	Water and nutrients lost through the soil profile into the wider environment
<b>Eutrophication</b>	The addition of artificial or non-artificial substances such as nitrates and phosphorous into waterways causing negative environmental effects such as excessive plant growth and reduced water quality.
<b>Drainage water</b>	Water that leaches through the soil profile without being evaporated or taken up for plant growth

## Key words:

Eco-n, nitrogen, environment, fertiliser, sustainability, dairy, effluent, pasture, soil, production, leaching, pollution, nitrate, nitrous oxide, innovation, diffusion, adoption, uptake, usage.

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# Chapter 1

## General Introduction

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### 1.1 Introduction

In a world where land area is fixed and population is growing, the demand for food is continually increasing and this can drive a continual increase in agricultural intensity. While increasing intensity is common across most enterprises, both agricultural and non-agricultural, it is the increasing intensity of New Zealand's dairy farming industry that is causing concern. This concern is coming from environmentalists, animal rights lobbyists and the general public as well as many of New Zealand's farmers and land owners.

The term 'Dirty Dairying' has become commonplace in New Zealand. Although the public may envisage effluent pouring into waterways and 'pugged' soil being sluiced into rivers and streams as the cause of dairy pollution, the majority of dairy farm pollutants come from nitrates in animal urine being leached into the waterways and nitrous oxide gas from animal urine being emitted into the atmosphere (Kelliher, Clark & Clough, 2007; Stopes, 1995; Whitehead, 1995).

Agricultural activities have numerous positive and negative effects on the environment (Briggs & Courtney, 1985). Some of these effects have major ramifications and Vitousek et al. (2009) are certain that human activity, particularly agriculture, has approximately doubled the amount of nitrogen input into the terrestrial nitrogen cycle. The risk of increased nitrogen levels is that some nitrogen may be lost into the wider environment, creating environmental hazards in waterways and aquifers. Eutrophication of waterways is just one of these risks (Briggs & Courtney, 1985) and high nitrate levels in drinking water pose health risks for humans including cyanotic conditions like 'blue baby syndrome' (Giupponi et. al, 2006).

The production and release of nitrous oxide gas is another concern for environmentalists. Nitrous oxide is thought to account for approximately 6% of the heating effect of greenhouse gases (Briggs & Courtney, 1985). Increased nitrous oxide emissions have been attributed to agricultural fertilisers and animal production (Cameron, Di & Moir, 2007).

There is also a growing concern about negative public perceptions of agriculture (Holloway, 2005). These perceptions range from concerns over animal treatment to concerns about future effects of pollution and soil degradation (Casimir, 2008).

In an effort to combat dairy farm nitrate and nitrous oxide pollutants, scientists at Lincoln University developed a nitrification inhibitor product which was commercialised and released by the Ravensdown Fertiliser Cooperative (Ravensdown) in February 2004 with the brand name eco-n™.

## 1.2 Nitrification Inhibitors

To explain the effects of nitrification inhibitors it is crucial to understand the nitrogen cycle in grazed pastures:

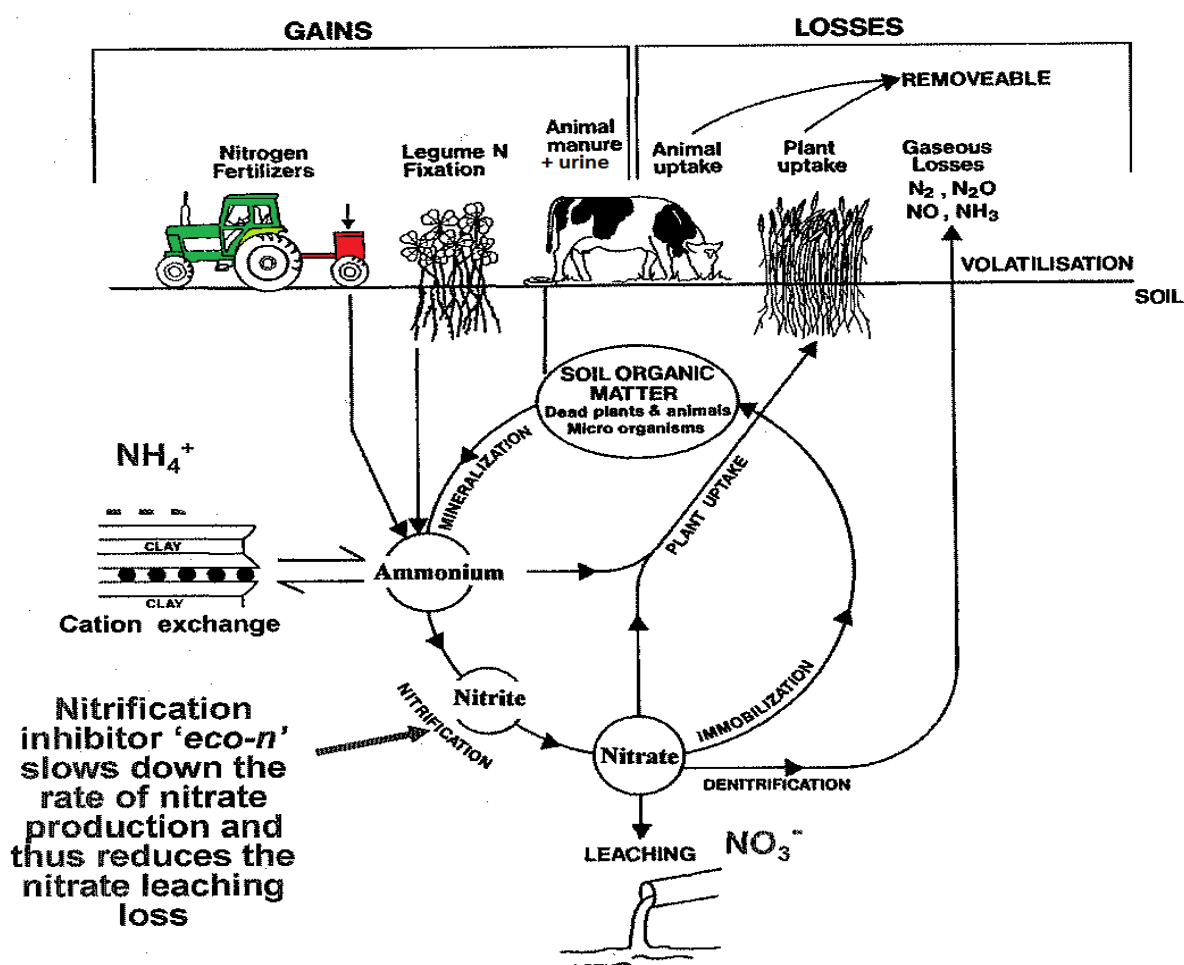


Figure 1.1 The Nitrogen Cycle in grazed pasture

McLaren and Cameron (1996) *Soil Science*. Oxford University Press. UK. 304p

Nitrogen, in the form of ammonium, is introduced into the soil as animal urine, nitrogen fertiliser and nitrogen fixation by legumes. The ammonium is then transformed into nitrates and nitrites by the nitrification process. During the growing season the nitrates in the soil profile are taken up by the pastures and used for growth.

During the winter there is less pasture growth so there is a considerable reduction in the amount of nitrates taken up by growing plants; there is also an increase in the amount of drainage water leaching through the soil profile without being evaporated or taken up for plant growth.

In usual conditions ammonium-nitrogen is converted into nitrate-nitrogen or nitrates within 20 to 50 days (Rajaratnam, 1966; Stevenson, 1986). The ammonium ion ( $\text{NH}_4^+$ ) is positively charged and can therefore be held in the soil by cation exchange on the negatively charged clay and organic matter particles. Nitrate ions ( $\text{NO}_3^-$ ) are negatively charged, so not only do they not attach to the negatively charged clay particles or organic matter, they are actually repelled from the clay particles and organic matter leaving the nitrate ions in the soil solution ready to be taken up by plants or, perhaps more importantly, leached through the soil profile by drainage water (Cameron, Di & Moir, 2007, 2009; Edmeades, 2004; Stevenson, 1986).

Nitrification inhibitors offer potential for decreasing nitrate losses by delaying the microbial transformation of ammonia-nitrogen to nitrate-nitrogen by slowing down the activity of soil nitrifying bacteria, such as *Nitrosospora* and *Nitrosomonas* (Cameron, personal communication, 2010). Therefore nitrification inhibitors can provide the potential for greater efficiency of nitrogen use, and a reduction in both the amount of nitrates available to be leached through the soil profile and the amount of nitrous oxide emitted into the atmosphere (Cameron & Di, 2002; Cookson & Cornforth, 2002; Kelliher, Clark & Clough, 2007).

The chemical name of nitrification inhibitors is dicyandiamide (DCD). Cameron & Di (2002) stated “The use of dicyandiamide has the potential to make dairy farming more environmentally sustainable by reducing nitrate leaching and nitrous oxide emissions”. This happens through dicyandiamide slowing down the activity of the nitrifying bacteria.

### **1.3 Ravensdown overview**

Ravensdown, established in 1977, is a farmer owned supply cooperative that supplies a comprehensive range of key farming inputs as well as technical advice to their farmer shareholders. Ravensdown have traditionally been a basic N,P,K,S solid fertiliser supplier, but over the past decade have extended their product knowledge and range to include agrochemicals, animal health products, lime and new technologies.

Ravensdown hold a 76% share of the South Island dairy fertiliser market (Morris, 2010).

## 1.4 Eco-n™ overview

Eco-n™ is the brand name given to the nitrification inhibitor or dicyandiamide product for sale by Ravensdown.

Dicyandiamide has been formulated into two proprietary brands in New Zealand, one is eco-n™, a Ravensdown product, and the other is DCn a product of Ballance Agri-nutrients. According to Edmeades (2010), recent trial work has shown that there is little to no difference in the efficacy between these formulations or between the generic and branded products, although this claim is disputed by Ravensdown (Morris, 2010, personal communication). Eco-n™ is a patented product but the patent is related to the methods used in the formulation and application of the product. The formulation and application of eco-n™ results in a superior performing product and in a superior application of the active ingredient (Cameron et al. 2009).

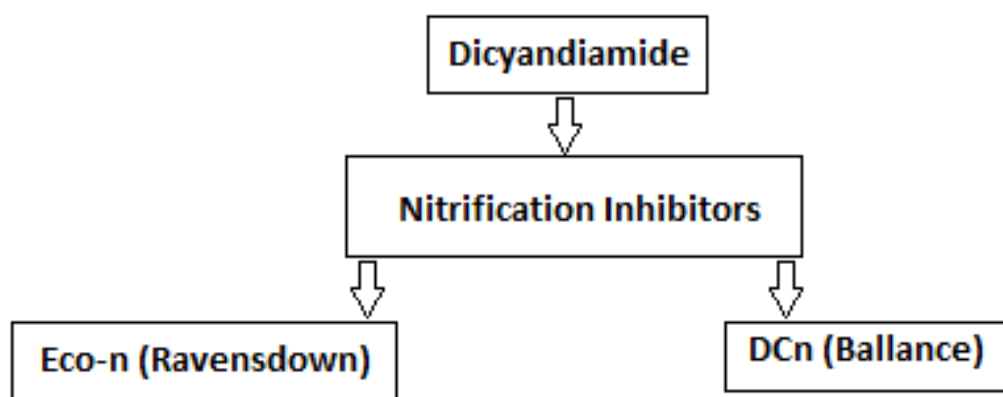


Figure 1.2 Dicyandiamide, nitrification inhibitors and eco-n™

Due to the half-life of dicyandiamide being approximately 45 - 50 days (Cookson & Cornforth, 2002) eco-n™ applied in late autumn breaks down before the drainage period is over. Eco-n™ therefore needs to be applied again, within 100 days of the first application, to provide protection until spring.

The best practice for use of eco-n™ is to apply the chemical in April so it is active in the soil before the period when growth slows and there are higher levels of rainfall. The dicyandiamide blocks the nitrification process so most of the nitrogen is held in the soil (in  $\text{NH}_4^+$  form) over the winter; however eco-n™ will need to be applied again in July or August. The trapped nitrogen, in theory, is then available for plant uptake in spring.

The recommended application rate of eco-n™ is 11kg/ha (Cameron, personal communication, 2010). It is crucial to apply this rate twice annually, resulting in an annual application of 22kg/ha.

The mean nitrogen content of dicyandiamide is 65% (Langelaan & Troelstra, 1992) so it can be assumed that pastures treated with eco-n™ receive approximately 13kg/ha of nitrogen, equivalent to 25kg/ha of urea.

The use of eco-n™ on a ‘typical’ grazed dairy pasture, according to Cameron et al. (2009), has three distinct benefits:

1. Nitrate leaching from urine patches is reduced by an average of 64%
2. Nitrous oxide emissions from urine patches are reduced by an average of 68%
3. Pasture production in the South Island can increase by up to 23%

### 1. Nitrate leaching from urine patches is reduced by an average of 64%

The effectiveness of eco-n™ use in reducing nitrate leaching from the urine patch on a stony Canterbury Lismore soil (Figure 1.3).

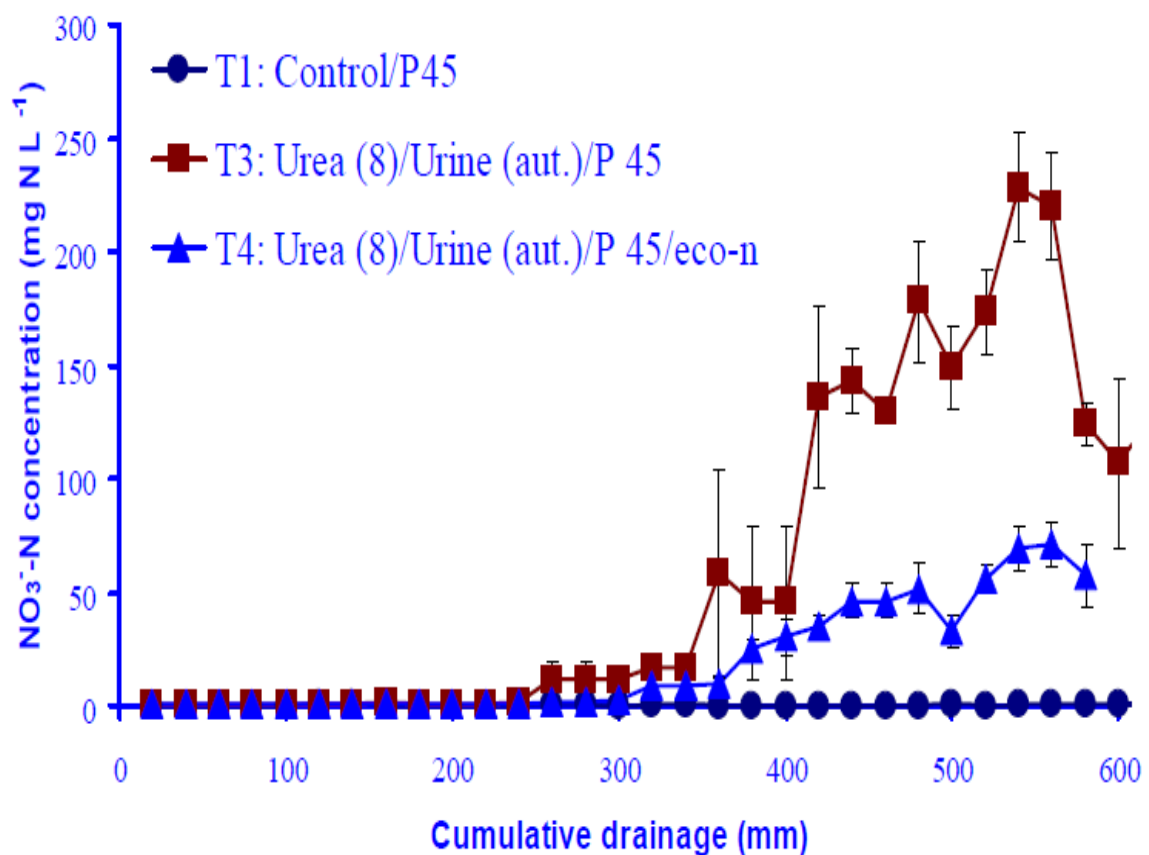


Figure 1.3 Nitrate leaching and eco-n™ (Cameron & Di, 2002)

## 2. Nitrous oxide emissions from urine patches are reduced by an average of 68%

The significant difference of the effect of DCD on N<sub>2</sub>O emissions following two urine applications can be seen in Figure 1.4:

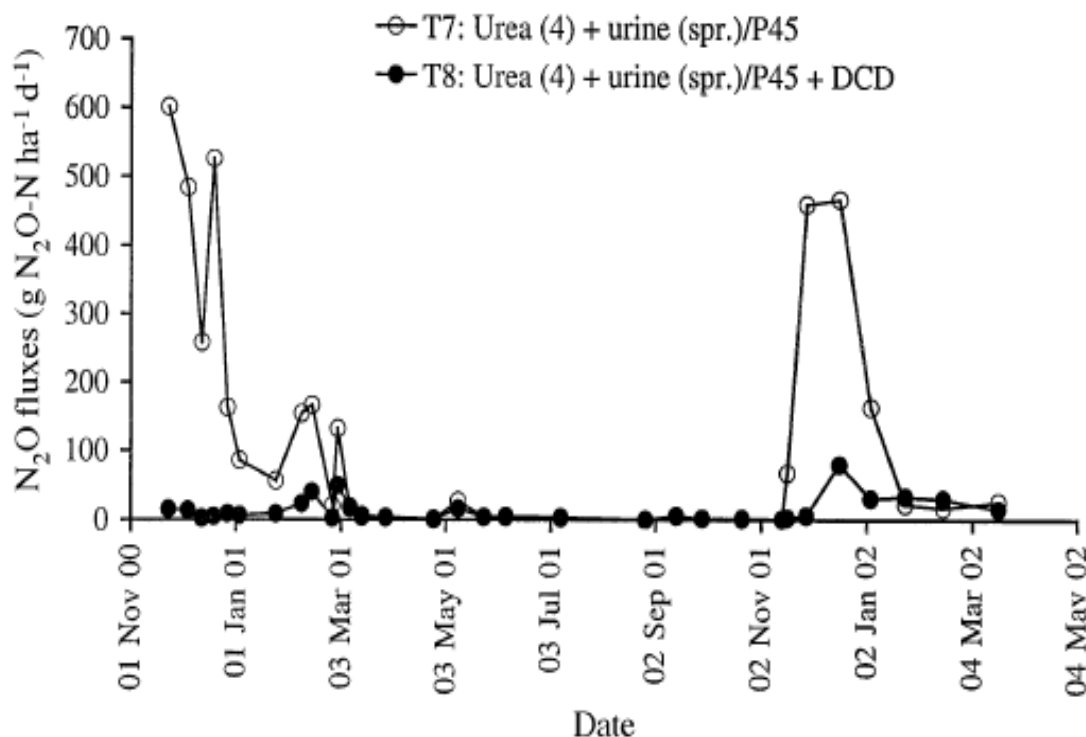


Figure 1.4 Nitrous Oxide emissions and eco-n<sup>™</sup> (Cameron & Di, 2002)

Cameron & Di (2002) explained that test conditions represent on-farm conditions extremely closely, with the urine used in testing being representative of the average New Zealand dairy cow urine in both composition and application rate (Cameron & Di, 2002).

## 3. Pasture production, in the South Island, can increase by up to 23%

Eco-n<sup>™</sup> use results in a higher soil-nitrogen composition which leads to increased plant-nitrogen content. According to Cameron et al. (2007), the increase in nitrogen content of plants and soils results in increased pasture production of up to 23%.

However, there is debate over the pasture growth figures and their variability. This debate arises over the relationship between the controlled test environment and the variable on-farm environment. Edmeades (2010) disputed some of the scientific methods used and some of the figures given in other articles and claims that any increase in pasture production can be

attributed to the nitrogen content of dicyandiamide. He also claims that the average increase in pasture production is 2%, rather than 23% as claimed by researchers. Edmeades (2010) argues that eco-n™ has been tested in a 'worst case scenario' environment and indicates that the figures published for reduced nitrate leaching and reduced nitrous oxide emissions cannot, and should not, be extrapolated to a normal farm scenario.

## **1.5 The spread of eco-n™ information**

Eco-n™ has been commercially available since 2004. The diffusion of eco-n™ information is largely accomplished by the Ravensdown Account Managers as part of the farm visitation process. The Account Managers explain the costs and benefits of eco-n™ to their dairy farmer shareholders and aid them in their eco-n™ decisions.

Eco-n™ information is spread in several other ways:

- via the Ravensdown website ([www.ravensdown.co.nz](http://www.ravensdown.co.nz)),
- via the Lincoln University Dairy Farm (LUDF),
- publications,
- advertising,
- field days
- word-of-mouth,
- early adopter influence, and
- independent farm management consultants.

Through all of the above methods it is proposed that the diffusion of the basic eco-n™ information has sufficiently spread throughout the Ravensdown dairy farmers.

## **1.6 Adoption of eco-n™**

The uptake of eco-n™ has been less than expected by Ravensdown who have a short term (2011) goal of a 25% usage rate over the South Island dairy market. The long term goal is to have eco-n™ applied to 50% of the total area farmed by their South Island dairy farmer shareholders (Morris, 2010).

On a land area basis, eco-n™ usage in Canterbury, Southland & Otago has been shown in Figure 1.5:

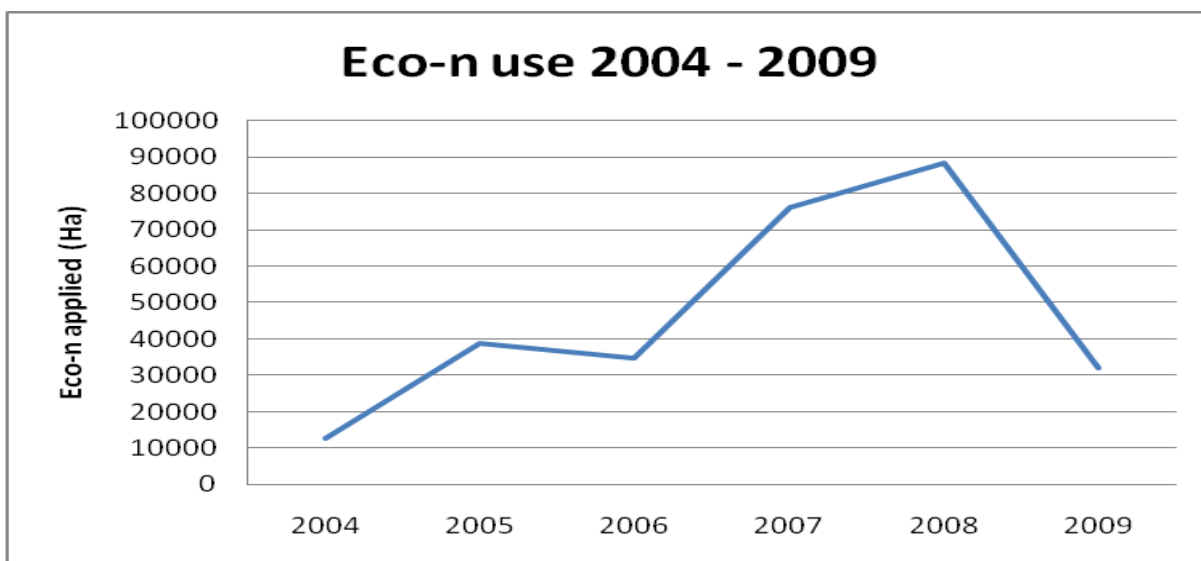


Figure 1.5 Eco-n™ use (Compiled from the Ravensdown database)

The percentage of dairy farmers in the research area using eco-n™ was 17% in 2008, but this User percentage dropped to 7.0% in 2009. This ec<sup>1</sup>o-n™ use fluctuation can be compared to the corresponding Fonterra<sup>(1)</sup> payout (Figure 1.6).

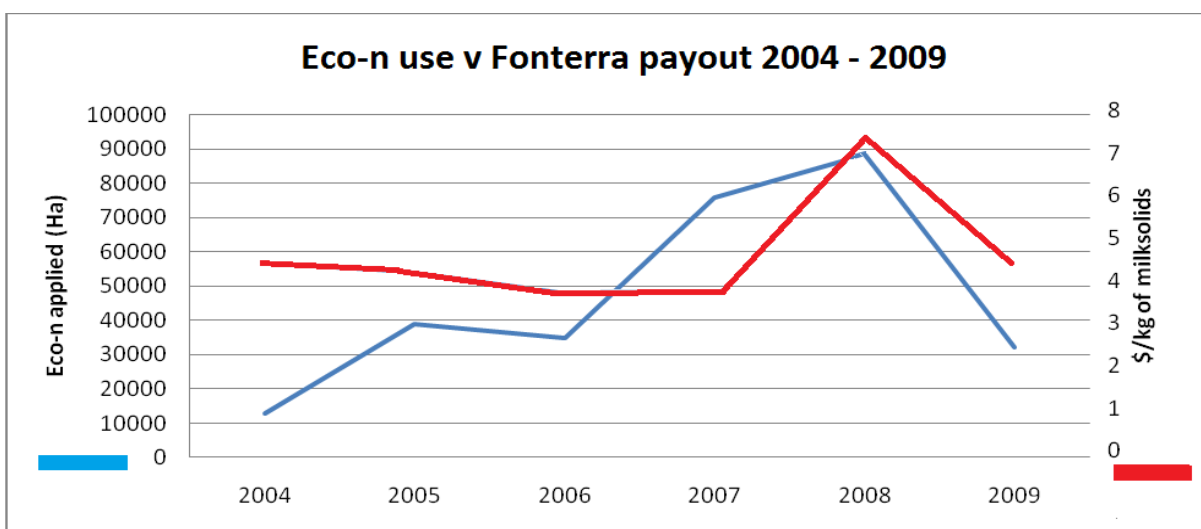


Figure 1.6 Eco-n™ use v Fonterra payout (compiled from the Ravensdown database and Fonterra.com)

The downturn in eco-n™ use between 2008 and 2009 coincides with a major drop in the Fonterra payout. This was a period when dairy farmers were under intense cashflow pressure.

<sup>1</sup> Fonterra is a cooperative dairy processor and marketer, handling nearly 90% of the New Zealand milk supply.

# **Eco-n™ Research**

## **1.7 Research Problem and Research Questions**

Ravensdown believes there are opportunities to increase the number of New Zealand's dairy farmers using eco-n™. This leads to the research questions listed below.

1. What are the patterns of eco-n™ usage?
2. What is limiting the uptake of eco-n™?
3. What elements contribute to farmers' decision making criteria regarding eco-n™?
4. How effective is the diffusion of information about eco-n™?

## **1.8 Research Objectives**

- Identify who is and who is not using eco-n™ and why
- Relate findings to the literature on agricultural innovation and adoption

## **1.9 The Research Area**

To answer the research questions sales data was obtained from Ravensdown and farmers in Canterbury, Otago and Southland were interviewed with farm locations spanning from Culverden to the Southland coast. The research area was restricted to Canterbury, Otago and Southland in the interest of practicality and time. It was also felt that a deeper understanding could be gained if variables such as location could be reduced. The selected research area has consistent geographical features, similar farm systems and similar stocking rates.

# Chapter 2

## Literature Review

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### 2.1. Innovation

Platier (1994, p.2) stated “Innovation is one of the driving forces, if not the prime mover, of economic and social progress”.

While this statement refers to innovation in a general sense, this project will discuss innovation in the context of business. Twiss (1974) believed New Zealand’s major industrial companies owed their existence to successful innovations and technologies of the past.

Rogers (1962, p.12) defined innovation as “an idea, practice or object that is perceived as new by an individual or other unit of adoption”. Afuah (2003) describes innovation as firms using or adapting new knowledge to offer new products or services that customers want. He also points out that an innovation does not necessarily require new knowledge. Someone may have had the knowledge for a long period of time. Innovation requires developing an attitude toward the knowledge, creating the technology and putting it into practice.

Innovations themselves can be placed into different categories. Bell (1963) defined innovations as either strategic or functional. Strategic innovations, he said, involve an existing product alteration and require little change from either the firm or the consumer, while a functional innovation requires a higher level of change for both the firm and the consumer. Innovations were more recently classified by Kotler & Trias De Bes (2003) as product innovations, size innovations, packaging innovations, design innovations and usage innovations.

Porter (1996) explained that successful innovation should result in economic benefits for the innovative company either by an increased profit per unit or an increase in the number of units sold.

## **Why does innovation occur?**

Regardless of the type of innovation, there are generally accepted reasons why innovation occurs (Afuah, 2003). Twiss (1974) suggested that Innovation occurs because there is a need for products that are currently not used in practice. Innovation will only result from this need if there is also a willingness to pay for the final product (Von Hippel, 2005).

Ulph (1994) explained that innovation is the only tool for justifying R&D expenditure. With a further comment that any R&D expenditure that does not lead to some form of innovation should be seriously scrutinised to determine the actual benefits of R&D. Porter (1996) explained how the innovation also has to survive pressures from buyers and sellers, competition from rivals and substitutes, as well as opposition from new entrants.

A number of authors have suggested reasons for the occurrence of innovations. A compilation of these reasons is:

1. Schumpeter (1939) attributed innovation to a search for profit.
2. Brown (1957) found that innovation resulted from a search for increased demand.
3. Ulph (1994) discussed how firms have to innovate either to get ahead of competing firms or to 'catch up' to existing competitors.
4. Shrinking profit margins for established products (Afuah, 2003).
5. Shorter lives of established products (Afuah, 2003).
6. Excess capacity (Afuah, 2003).
7. The need to overcome an identified inefficiency or conflict (Bogardus, 2004).

Sustainability and environmental protection are becoming common drivers of innovation. From the mid 1980s businesses have been aware that a small but growing group of well informed consumers are willing to pay a premium for environmentally friendly products and initiatives (Ford, 1992). Innovation can be driven by the increasing international need for environmental protection and is often a response to changes in the physical environment and firms are encouraged to innovate for reasons beyond financial gain, including better customer relations and social awareness (Kemp & Arundel, 1998). In addition, society is becoming increasingly concerned about the environment and more innovations are being driven by the needs and wants of environmentally conscious consumers (Glaeser, 2005).

## **Additional points about innovation**

Most new products generate some level of interest from customers. Robertson (1971) discussed how innovative new products can attract consumers just because they are 'new' and argues that a product with no changed characteristics would be purchased over the existing product if the product was labelled as 'new'. Robertson (1971) went on to point out that the Federal Trade Commission (FTC) in the USA limits the use of the word '*new*' to six months after the product enters regular distribution.

Platier (1994) stated that innovation was more important than it had been in the past (due to rising costs of energy, decreasing access to raw material, etc.), while also discussing the claim that western countries no longer had the innovative vitality of previous generations. Platier (1994) justified this statement by indicating that the 'western quality of life' was comparatively high while less developed countries needed continual, intense innovation just to improve the quality of life and reduce infant mortality and child mortality.

Lionberger (1960), Platier (1994) & Porter (1996) discussed potential innovation obstacles and identified factors such as education and training levels, credit availability, institutional arrangements, access to raw materials, motivation and foreign trade. Platier (1994) also identified the increasing level of technology transfer, both nationally and internationally, as one of the biggest barriers to innovation.

Innovation of products usually induces additional changes in supply networks and other operations. This creates a requirement for a full investigation of the externalities involved with any innovation before the innovator can gain a true understanding of the practicality or adoptability of the innovation (Forbord, 2005).

## **2.2. Diffusion**

There has been debate over the meanings of the words 'diffusion' 'dissemination' and 'extension'. In this study the word diffusion will be used interchangeably with the words dissemination and extension so the word deals with not only the direct dissemination (agent – farmer) of information but also with the 'farmer-farmer' diffusion of the information. "Diffusion is the process by which an innovation is communicated to members of the community for which it is intended" (Rogers, 1962, p.5).

Rogers (1962) stated that diffusion is a special type of communication where the messages communicated are concerned with new ideas. It is a process in which participants create and share information with one another in order to reach a mutual understanding (Rogers, 1962).

### **What factors affect diffusion?**

There are basic elements that must be present for there to be any level of diffusion and Rogers (1962) identifies four basic elements required for the successful diffusion of innovations:

- 1. The innovation**
- 2. Communication Channels**                      *-The means by which information passes between people*
- 3. Time**    *-The time for information to spread and to be adopted*
- 4. A social system**                              *-A group sharing a common problem or goal*

If all four of the listed elements are present there should be some level of successful diffusion. Diffusion requires at least two participants, one who has knowledge of the innovation and one who has no knowledge of the innovation. Diffusion then requires a communication channel to connect the two (Rogers, 1962).

The rate of uptake of the product, or response to the diffusion, is affected by another group of factors that relate directly to the innovation itself. The product or the innovation plays an important role in the diffusion process and according to Rogers (1962), exciting, new and applicable products will diffuse much more rapidly than small changes to an existing product.

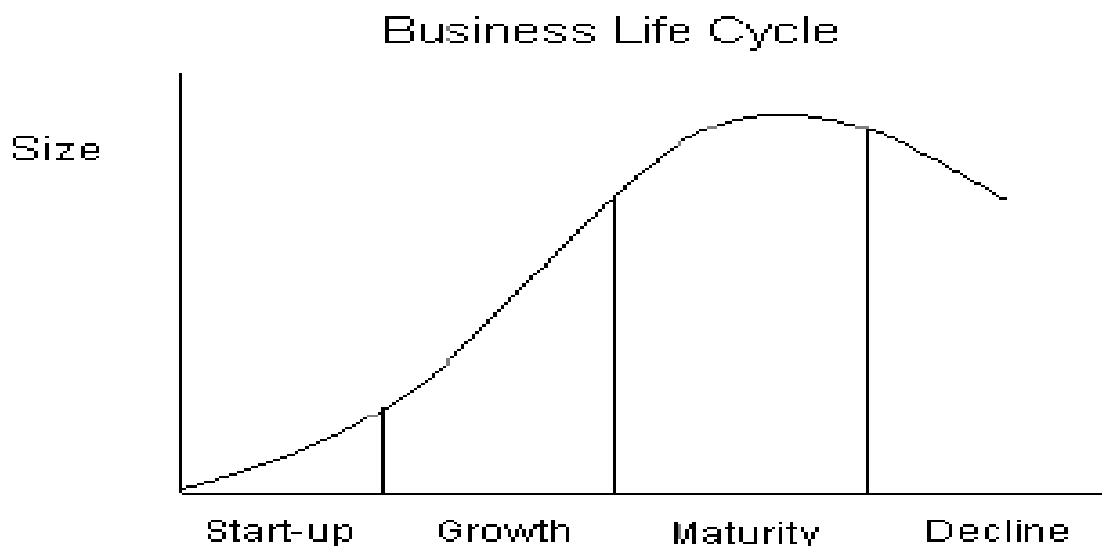
According to Scheuing (1989), the rate of diffusion can be attributed to five different factors.

1. The innovation's relative advantage over competing products
2. The innovation's compatibility with the prospect's lifestyle / operation
3. The innovation's complexity in comprehension and use
4. The innovation's ability to be trialled on a limited scale
5. The observability / communicability of the innovation's benefits

## The business lifecycle

Depending on where the business is in its lifecycle, there will be different strategies behind the innovation and different capabilities within the business (Chapman, 2005). Where the business is in the business lifecycle will affect not only the type of innovation but also the ability to diffuse information about the innovation. Chapman (2005) goes on to claim that large established companies can diffuse information much faster, more broadly and more effectively than small developing companies.

The business lifecycle has four stages – start-up, growth, maturity and decline (Chapman, 2005). Where the business is in its lifecycle has a substantial impact on diffusion.



*Figure 2.1 Business lifecycle (Iowa State University, 2010)*

## 2.3. Adoption

If there is a degree of successful diffusion, backed up by a desirable product, it should be followed by a degree of successful adoption. The decision to adopt a technology is rarely a sudden, abrupt decision but rather the result of a sequence of events and influences over time (Lionberger, 1960). Brown (1981) explained the adoption of an innovation is the outcome of a learning, communication or diffusion process.

There is often a substantial difference between the number of people exposed to an innovation and the number of people who adopt an innovation (Rauniyar & Parker, 1998). “The adoption process is influenced by consumer characteristics such as personality traits and demographic or socioeconomic factors, the characteristics of the new product - such as its relative advantage over existing products, complexity, and the effect of social influences such as opinion leaders” (Narayanan & O’Connor, 2010, p.115).

Firms are often disappointed with the seemingly restricted diffusion and adoption of their innovative products (Lionberger, 1960). This phenomena is known as the ‘pro-innovation bias’ which Rogers (1962) described as innovators assuming their product should diffuse more rapidly; it should be adopted by everyone and it shouldn’t be rejected or reinvented.

Landstrom (2005) explained how the passion and excitement created by an innovation usually leaves the innovators with overly optimistic expectations of how successful the diffusion and adoption will be. Many technologists believe that advantageous innovations will sell themselves, that the obvious benefits of a new idea will be widely realised by potential adopters, and that the innovation will diffuse rapidly. Landstrom (2005) concluded that this is seldom the case. Most innovations, in fact, diffuse at a disappointingly slow rate, at least in the eyes of the inventors and technologists who create and promote them.

### **Adoption decisions**

Lionberger (1960, pp.3-4) identified five stages that consumers appear to go through when faced with a new technology - “Awareness, Interest, Evaluation, Trial and Adoption”. The decision making process may not be clearly divided into separate stages as suggested by Lionberger’s list. The stages may be blended and overlapping and it may be impossible to identify when and where one stage finishes and another begins.

The levels of engagement into this decision making process will differ between different potential adopters, and individual adopters will have differing levels of decision intensity depending on the innovation involved.

Lionberger (1960) also said the adoption decision making process may be re-started again after an innovation has been adopted. Potential adopters can reject a technology at the awareness stage and likewise adopters may not reject a technology until after they have adopted the technology and then re-started the adoption decision process. “Even after an individual has

made the decision to adopt a technology, evaluation and trial stages are often by no means over” (Lionberger, 1960. p.66).

Lionberger (1960) defines step one (awareness) as a responsibility of the firm and steps two through five as predominantly the responsibility of the product. He concluded that even with a ‘good’ product, the decision making process can still take time because failure (of the firm) to achieve stage one, results in the non-achievement of stages two to five.

Rogers (1962, p.164) built on the five stages of adoption and explained an innovation decision process:

<b>“Knowledge</b>	Occurs when an individual is exposed to the innovation
<b>Persuasion</b>	Occurs when an individual forms an attitude toward the innovation
<b>Decision</b>	Occurs when an individual engages in adoption or rejection activities
<b>Implementation</b>	Occurs when an individual puts the innovation to use
<b>Confirmation</b>	Occurs when an individual seeks confirmation of their decision”

Lionberger (1960) also concluded the greater the costs involved in technology adoption or the more substantial the change will be, the more likely a potential adopter is to engage deeply in the decision process. Scheuing (1989) identified that the more complicated a technology is, the slower the adoption process. He also concluded that if the complicated change can be broken down into smaller, more manageable stages the adoption process may progress more quickly.

### **The technology adoption lifecycle**

The technology adoption lifecycle is the concept that ‘the market’ is made up of different groups depending on their engagement with new technology, personal and communication factors, as well as other distinguishing characteristics. The notion of the technology adoption lifecycle has been supported by many diffusion and adoption theorists (Moore, 1999; Rogers, 1962; Scheuing, 1989; Twiss, 1974; Von Hippel, 2005).

The groups are classified into innovators, early adopters, early majority, late majority and laggards (Rogers, 1962).

Table 2.1 Summary profiles of adopter categories (Rogers, 1962, p.315):

Adopter Category	Key characteristic	Personal aspects	Communication sources
Innovators	Venturesome	Young, high income	Scientific and impersonal
Early adopters	Respectability	Community leaders	Local sources
Early majority	Deliberate	High social status	Early adopters
Late majority	Slow	Low social status	Early majority
Laggards	Traditional	Lowest social status	Peers

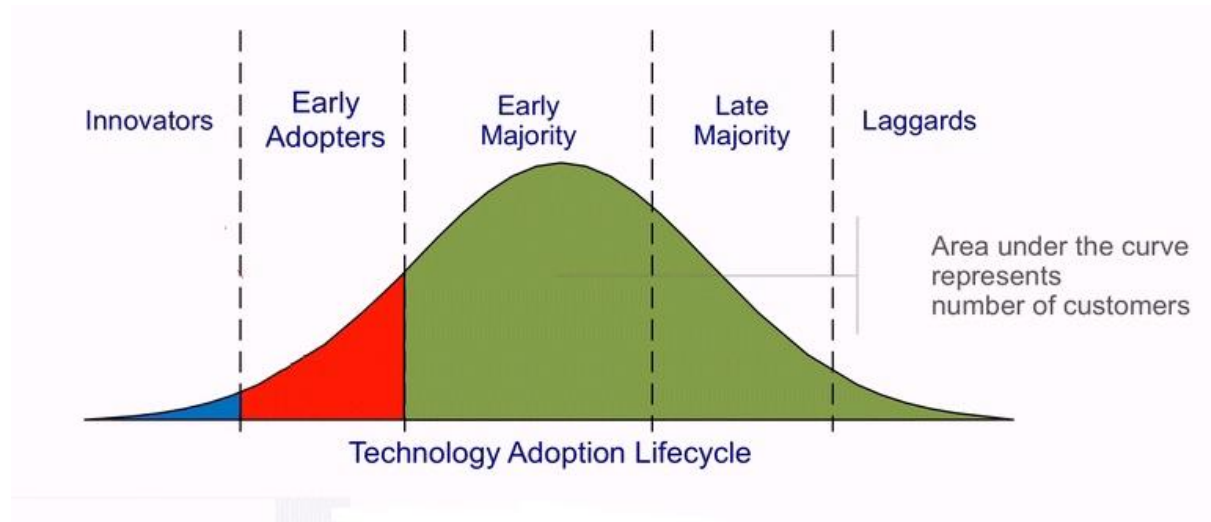


Figure 2.2 Technology Adoption Lifecycle (Rogers, 1962)

Theorists have agreed that each group influences the next group, or that each group uses the previous group as a reference (Von Hippel, 2005). The early adopters use the innovators as a reference and adopt technologies that appear to work for the innovators, the early majority are then influenced by the early adopters who are using the technology and so on (Moore, 1999; Rogers, 1962; Twiss, 1974). Many business plans are based on the assumption that the way to develop a market is to work through the curve from left to right, progressively 'capturing' each group and then using that 'captured' group as a reference for the next group (Moore, 1991).

However, this theory has been disputed by further research and other theorists who believe there are gaps or barriers between the different groups. Moore (1999) discussed 'The chasm' between and within the different groups and argues that 'The chasm' is most pronounced within the early adopters group (Figure 2.3).

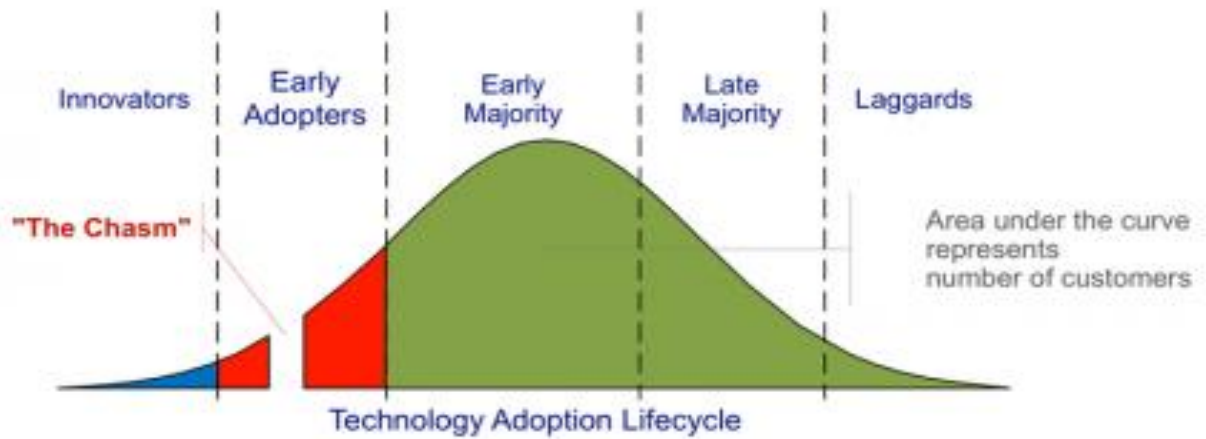


Figure 2.3 The Chasm of the Technology Adoption Lifecycle (Moore, 1999)

Moore (1999) concluded that the early majority use other early majority farmers as reference and are influenced very little by the decisions or actions of the early adopters. The diffusion of information and the power of influence does not easily pass between these fundamentally different farmers. Moore (1999) went on to say that successful adoption processes achieve a bridging of the chasm and can penetrate a segment of the early majority. Diffusion should then occur within the early majority as these farmers use other early majority farmers as a decision making reference. Moore (1999) also stressed the importance of the product in influencing and supporting this pattern.

### **Adoption effects on innovation**

Brown (1981) eluded to the point that innovation diffusion and adoption will often lead to improvements to the innovation as the different applications of the technology identify different factors or problems. The important factor is to ensure that communication channels are present and open so information about the technology can diffuse back to the technology developers (Brown, 1981).

### **Adoption risk**

Adoption of new technology usually presents some level of risk and diffusion strategies should be aimed at minimising the perceived risk involved with adoption (Rogers, 2003). Potential adopters may be hesitant to adopt an innovation because they cannot quantify or handle the risks involved.

A major factor that may increase or mitigate the identified risks involved with technology is the costs involved (both financial and non-financial) in reversion (Rogers, 1962). If the technology can be trialled and then rejected at no great costs then the risk around adoption is reduced. If the technology use requires major changes that will create a sunk cost if the technology use is discontinued then the risk around adoption is increased (Lionberger, 1960).

Scheuing (1989, p.309) identified five types of risks for potential adopters of an innovation:

<b>“Financial Risk</b>	Potential loss of money if the product does not perform satisfactorily
<b>Functional Risk</b>	Risk that the product will malfunction or fail performance expectations
<b>Physical Risk</b>	Risk of the new product inflicting physical harm to the user
<b>Psychological Risk</b>	Potential psychological discomfort resulting from a poor choice
<b>Social Risk</b>	Potential loss of face or respect in the eyes of relevant others”

Potential adopters will attempt to minimise all of these risks before committing to using an innovation (Scheuing, 1989). During the adoption decision process potential adopters are looking for trusted reassurance which should be provided by the diffusion function (Scheuing, 1989). According to Johnson (1994), It is important to note that farmers have differing levels of risk perception, risk comfort, technical knowledge and future outlooks.

In summary, there is a range of variables affecting the rate of adoption of innovations. These variables include, but are not limited to, those discussed in this section and those outlined by Rogers (1962) (Figure 2.4).

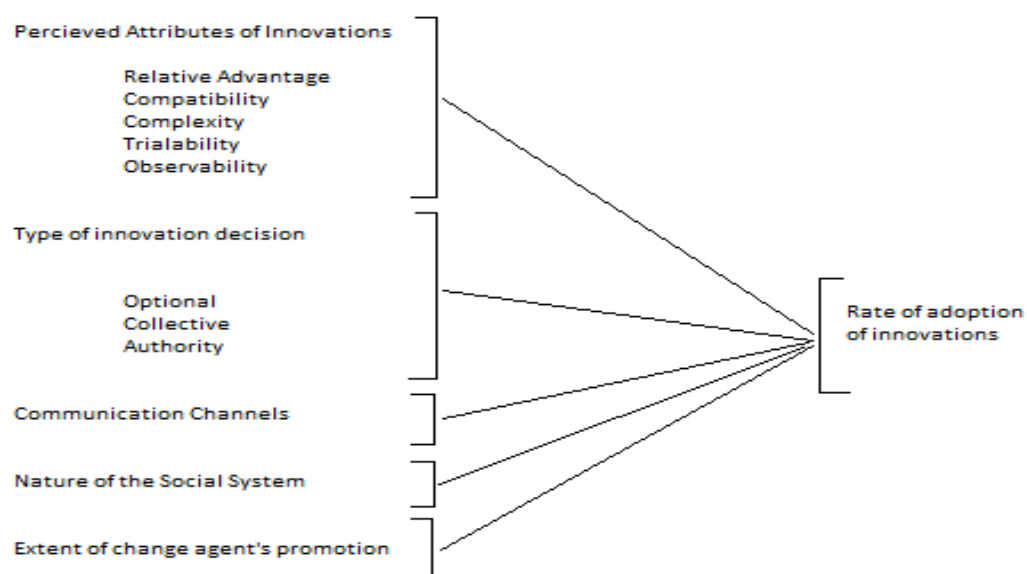


Figure 2.4: Paradigm of variables affecting the rate of adoption of innovations (Rogers, 1962)

## **2.4. Innovation, diffusion and adoption of agricultural technologies**

Understanding the diffusion and adoption of agricultural innovations is important for people all over the world and has long attracted interest from a range of parties from farmers to development economists (World Bank, 1981). The reason for interest in this topic, particularly in the 20<sup>th</sup> in century, was that most countries in the world depended on agriculture for their survival. Many of these countries also relied on agriculture as a major contributor to gross domestic product (GDP).

Fairgray (1979) classified agricultural diffusion into two main stages. The first stage is a small localised diffusion restricted to those who have direct and regular contact with extension officers. The second stage is a low intensity, indirect spread of influence, with knowledge and attitudes below the threshold levels of intensity needed for rapid adoption.

Roling, Ascroft & Wa'Chege (1994) claimed that generalisations made about diffusion by previous theorists, while well presented and clear, did have some drawbacks as these theorists had drawn conclusions about diffusion practices that were already in use, when in fact they had done little theorising on what is optimal practice. Roling, Ascroft & Wa'Chege (1994) also explained that diffusion strategies used by firms in the rural sector can be accused of increasing the level of inequity between farmers.

Technological developments have led to huge increases in agricultural product quality and in the level of agricultural output. However, many of the technological advances made in agricultural history have met some resistance during their introduction (Rauniyar & Parker, 1998).

Johnson (1994) highlighted the misconception that farmers are homogenous as a cause of unsuccessful diffusion in agriculture. Farmers have differing levels of risk perception, risk comfort, technical knowledge and future outlooks which diffusion theorists and marketers alike should take into account when determining the optimal extension and diffusion programmes for agriculture (Johnson, 1994).

At the time he conducted his study Robinson (1990) concluded that because many agricultural developments reduce labour demand, agricultural technologies can dramatically impact upon the farming population and on rural society in general. This aligns with Barley (1989) who said changes that might, in other situations, affect only the firm may affect the entire rural community. Additionally people in rural societies have traditionally had more difficulty accepting

changes to social and historical norms (Bradley & Lowe, 1984). Degregori (2001) claimed the reason agricultural innovations have traditionally been met with more resistance than non-agricultural innovations is that there has been a higher degree of technophobia in rural society.

The perceived technophobia and traditional mindset of rural communities in the 20<sup>th</sup> century has changed considerably and farmers are now willing to adopt a range of innovations (Glaeser, 2005). Innovation in agriculture has traditionally been driven by a need for increased production while recently technologies have been aimed at sustainability and environmental friendliness (Glaeser, 2005).

Canter (1986) concluded that there are varying levels of public consideration for the environment and that these variances are more predominant in agriculture. Edwards & Wali (1993) concluded that while there is a range of consideration for the environment, there is a responsibility on all farmers to exercise some care for the environment. Brouwer and Ervin (2002) found that public perception is not a strong enough driver to stimulate farmer behavioural change. Meister (2002) commented that farmers in New Zealand can be held responsible for the environment via the Bio Securities Act (1993), the Animal Welfare Act (1999), the Resource Management Act (1991) and the New Zealand Food Act (1981).

Because farmers may not be driven by public perceptions or environmental concerns, they may need to be convinced of the economic and production benefits of a product. “Producers adopt new agricultural technologies based on the expected economic benefits gained from the technology” (Walton et al. 2008, p55). Kaine, Lees & Wright (2007) concluded that total adoption of agricultural innovations is expected to be strongly correlated to the value given to the innovation by those farmers for whom it is relevant.

Robertson (1971) profiled the characteristics of an innovative farmer and claimed that the farmers who have all these characteristics are the farmers who are most likely to lead innovation. A summary of that profile is as follows:

<b><i>Demographics</i></b>	Innovation is positively related to education level and social status. Income can be related to farm size, social status and innovation.
<b><i>Communication</i></b>	Innovators are found to have a greater exposure to sources of information. They are found to have more media, scientific and extension contact as well as more farm magazine contact.

- Social Interaction*** Innovativeness and opinion leadership are positively related. The innovator will tend to be an influential person. In some cases they can be somewhat deviant as innovation can require breaking social norms.
- Attitude & personality*** Innovators are venturesome, open-minded and willing to accept risks. They often perceive themselves as innovators.
- Farm Management*** Generally, the larger the farm the more open farmers are to innovation. Innovation is also more accepted where there is the use of cost accounting and production measuring systems.

Scheuing (1989) identified some basic requirements for successful agricultural adoption, and stated that adoption is likely to be faster with young, educated farmers who are willing to break with tradition. He also found that adoption will be more likely on larger, profitable farms which are more financially stable and have successfully adopted new technologies in the past.

After considerable research Walton et al. (2008) found that the farmers who were most likely to use technologies such as precision soil sampling had the following characteristics:

- younger producers,
- comparatively larger farmed area,
- less debt, and
- used a computer

Both Walton et al. (2008) and Scheuing (1989) identified the key characteristics of innovators as younger farmers with financial stability who farmed a larger area and had successfully adopted innovations in the past.

## **2.5 The agent's role in diffusion and adoption of agricultural technologies**

Rogers (1962) identifies the change agent as one of the major drivers in the diffusion and adoption of an innovation. Past research into agricultural innovation has identified that concentrating on the innovation alone does not provide sufficient understanding, especially when the innovation is developed and marketed by an entity motivated to create rapid and complete diffusion (Brown, 1981; Brown & Cox, 1971). Brown (1981, pp.50) claimed that "the mechanisms through which innovations are made available to potential adopters is of equal if not greater importance than the innovation itself".

In the case of Ravensdown and eco-n™, Ravensdown is the sole agent and is therefore responsible for both stages of diffusion as defined by Brown (1981). These two stages are diffusion agency establishment (providing distribution points) and agency operating procedure (conceiving and implementing a strategy to promote adoption among the target market).

## **2.6. Unsuccessful Innovations**

What makes a new product successful? And what separates successful products from failed products? These two questions must be answered to allow both the reader and the author to gain an understanding of some of the factors that affect new product success. Cooper and Kleinschmidt (1987) explained that between 1984 & 1987, 46% of the resources dedicated to new product development in the USA were allocated to failed products. Cooper and Kleinschmidt (1987) also noted that 35% of the products launched commercially in the USA during the same period were failures.

Calantone & Cooper (1979) listed a variety of reasons for product failure and they point out the nine most prominent reasons:

1. "Competitors were more firmly entrenched in the market than expected
2. The number of potential adopters was overestimated
3. The price was set too high
4. The product had design, technical or manufacturing difficulties or complexities
5. Selling, distribution or promotional efforts were misdirected
6. The product was the same as competitors'
7. Customer requirements were misunderstood
8. Selling, distribution or promotional efforts were inadequate
9. A similar competitive product was introduced"

Although 30 years old, Calantone and Cooper's list provides a good indication of the various factors that may lead to a product failure. The list shows that new products are affected by a wide range of forces and threats. Innovative companies must attempt to understand as many of the drivers as possible when considering market entry or strategy (Calantone & Cooper, 1979).

# Chapter 3

## Methodology

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### 3.1 Introduction

This section outlines the methods used to answer the research questions and aims to give the reader an understanding of how the research was carried out and how the information was compiled to form the results in Chapter 4. As recommended by Seale (2004), it is appropriate in social research to have a loose division between the literature review and the methodology discussion. To this end, this section, like the Introduction section, will incorporate some published literature to give both the author and the reader an understanding of this research project's literary credentials and real world context.

In order to answer the four research questions it was necessary to complete two separate research projects:

The first research project involved answering question 1 – What are the patterns of eco-n™ usage? To answer this question the Ravensdown customer database was analysed and the resultant information was compiled into graphic figures and tables.

For the first research project the research area was split into three different zones. These classifications align with the information structure of the Ravensdown customer database - Upper, Central and Lower South Island (Figure 3.1).

The second research project involved a mixed method of qualitative case studies compiled from 108 'one on one' farmer interviews and quantitative analysis of the results. The quantitative analysis involved the use of both Microsoft Excel™ and the Statistical Package for Social Science (SPSS, 2010). This mixed method was a necessary approach to answer research questions two through four and to gain understanding of the elements that contribute to farmer decision making regarding eco-n™.

For the second research project the research area was split into only two 'agro-physically' similar zones - 'Zone 1' consisting of Canterbury and North Otago and 'Zone 2' consisting of South Otago and Southland (Figure 3.2).

### 3.2 Project 1      Data Analysis of patterns of eco-n™ usage

This section relates to question 1 (What are the patterns of eco-n™ usage?) and simply involves data analysis. The data was provided by Ravensdown in the form of the South Island dairy customer database and the researcher has collated and analysed the figures to derive usage rates for different groups and sub groups. This analysis also allowed for the identification of the 2009-Users, Churners and Non-users of eco-n™ - for section 2 of the research.

The usage analysis follows the three area classifications used by Ravensdown – Upper, Central and Lower South Island.

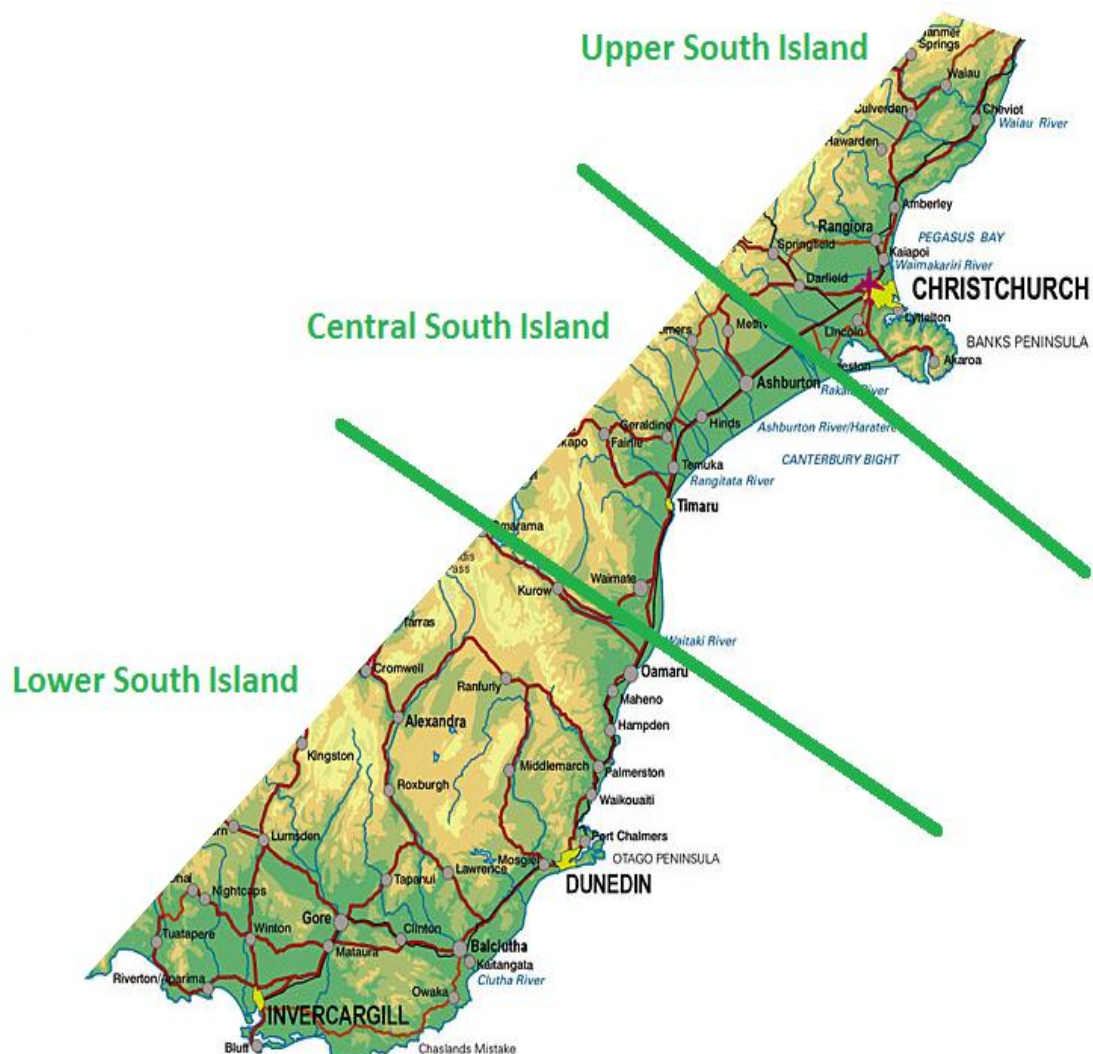


Figure 3.1 Area classifications for usage analysis

### **3.3 Project 2      Mixed method analysis of farmer decision making**

This is a mixed method research project combining both a qualitative case study and quantitative analysis of the case study results. The research for this project gathered information about the farm, the farmer, the farm system, the production and the climate. The research draws relationships between these farmer characteristics and eco-n™ use.

The case study method is an appropriate research tool to collect the required information to answer the research questions and to achieve the research objectives. The qualitative case study is recommended for agricultural research projects of this nature by Eisenhardt (1989), Holmes (2006) and Kaine, Lees & Wright (1994).

Yin (1994, p.13) described a case study as “an empirical enquiry that investigates a contemporary phenomenon within its real-life context when the boundaries between context and phenomenon are not clearly evident”. This means a case study is appropriate when the researcher believes context is strongly related to phenomenon. In this case ‘phenomenon’ is eco-n™ usage and ‘context’ is farmer and farm characteristics. Yin (1994, p.13) goes on to identify the actual case study enquiry as being “able to cope with a technically distinctive situation in which there will be many variables of interest”. Yin (1994) described how the case study approach comprises an all encompassing method and case studies can be designed with respect to other actions like data collection and data analysis.

Stake (1995) stated that the most distinctive characteristic of a qualitative case study is the possible variability in the interpretation of results. The design of the analysis and the development of instruments is often left until after the data collection process, so qualitative research requires dynamic capabilities as the researcher may need to redirect or refine the questions (Stake, 1995).

In contrast to many criticisms, Patton (2002) claims that a well constructed case study is both holistic and context sensitive.

Using a case study approach constitutes a specific way of organising, collecting and analysing data and in this sense a case study represents an analysis process (Patton, 2002). Case studies allow the researcher to gather and collate large quantities of different information both actionable and contextual which sets the scene for the data analysis process (Flyvbjerg, 2004). After the data collection stage is over the researcher needs to complete some form of statistical

analysis to identify common answers and responses to the questions which could then be used as research results (Flyvbjerg, 2004; Kelle, 2004; Patton, 2002; Stake, 2004).

The case study method will give this research project validity in the farming community as it is based on real life examples. This may mean that the farmers will have more respect for, and more easily relate to, this type of research as it shows the attitudes of their peers as opposed to those of research scientists and sales people.

### **3.4 Research approach**

In order to identify and understand the decision criteria that farmers are applying to eco-n™, a series of interviews were conducted with a selection of 108 Ravensdown dairy farmer clients, this number being 4.7% of the Ravensdown client farmers in the research area. There were 2302 dairy farmers that met the two basic requirements of a) being a Ravensdown shareholder and b) being located in either 'Zone 1' or 'Zone 2' (Figure 3.2). Section 3.5 explains the stratification process and will justify and explain the figure of 108 participants.

### **3.5 Stratification**

As espoused by Kaine, Lees & Wright (1994) the effectiveness of diffusion in agriculture can be better understood if the farms or farmers involved in the research can be classified into relatively homogeneous groups. This leads to the stratification process of dividing or stratifying a large group of farmers into smaller sub-groups with common characteristics. Kaine, Lees & Wright (1994) developed this theory further and claimed that differences in farm or farmer context will influence the level of adoption of technology. So, not only does stratification allow for better understanding of diffusion and adoption, it also allows for the identification of different levels of diffusion and adoption success across different sub-groups.

In this case the farmers were stratified depending on their use of eco-n™, their total fertiliser use and their location.

The division of the research area into two zones (one consisting of Canterbury and North Otago, and the other consisting of South Otago and Southland) can be seen in Figure 3.2:



Figure 3.2 Area classifications for case study research

The two distinct areas ('Zone 1' and 'Zone 2') were again split by the level of fertiliser use. The division of fertiliser use is by farmers who use more or less than 425 tonne of fertiliser annually. The level of annual fertiliser use set at +/- 425 tonne aligns with the classification system used by Ravensdown who broadly classify <425 tonne of annual fertiliser use as a Standard Account while >425 tonne is classified as a Key Account (J. Hodgkin, personal communication, 2010).

Dividing the clients into two different areas and two different levels of fertiliser use resulted in four different groups:

- Zone 1 users of less than 425 tonne of fertiliser annually
- Zone 1 users of more than 425 tonne of fertiliser annually
- Zone 2 users of less than 425 tonne of fertiliser annually
- Zone 2 users of more than 425 tonne of fertiliser annually

These four groups were then divided by their use of eco-n™ which gave a further three classifications:

- 2009-Users (2009 users of eco-n™)
- Churners (have used eco-n™ at some point between 2004 – 2008, but not in 2009)
- Non-users (never used eco-n™)

Dividing the four groups into three different levels of eco-n™ use resulted in a total of 12 groups containing 2302 farmers:

*Table 3.1 Stratification*

Location	Fertiliser use	Eco-n use	Number
Zone 1	< 425 t	2009-Users	47
		Churners	212
		Non-users	596
Zone 1	> 425 t	2009-Users	48
		Churners	115
		Non-users	139
Zone 2	< 425 t	2009-Users	36
		Churners	124
		Non-users	786
Zone 2	> 425 t	2009-Users	31
		Churners	55
		Non-users	113
Total farmers			2302

The 2009-User group accounts for 7% of the farmers in the research area, the Churner group accounts for 22% and the Non-user group accounts for 71%.

From each of the 12 stratified sub-groups 15 prospective farmers were randomly selected using a random number generation process as instructed by Woodford (personal communication, 2010) and this activity ensured a stratified random sample.

The researcher contacted 148 farmers via mail with a letter (Appendix B) containing a basic outline of the research project and what their participation would involve. The researcher then followed with a phone call in an attempt to secure 108 participants (9 farmers x 12 groups) for the research project.

The number of initial letters posted was dependent on the sub-group characteristics of eco-n™ use.

- From the potential 60 **2009-Users** (15x4) 44 letters were sent (**11 per group** x4)
- From the potential 60 **Churners** (15x4) 48 letters were sent (**12 per group** x4)
- From the potential 60 **Non-users** (15x4) 56 letters were sent (**14 per group** x4)

The number of letters sent to the Non-user and Churner groups (14 & 12 respectively) were higher than the number sent to the 2009-User group (11) as it was expected that Non-users and Churners might be more likely to refuse participation compared to the 2009-Users. It was expected, and eventuated, that some members of these groups had negative feelings toward eco-n™ and declined to participate.

### 3.6 Data collection

In June, July and August of 2010, the researcher travelled throughout Canterbury, Otago and Southland and interviewed each of the participants individually. The interviews lasted for approximately 30 minutes. The initial stage of the interview process consisted of 18 questions aimed at gathering profile information about the farm and the farmer. These questions, although open questions, were brief and mostly required a one-word or single-figure response. The second stage of the interview was in regard to eco-n™ and farmers were asked up to ten broad, open questions. There was no list of potential responses and no prompts. The farmers were able to give any response they wished, worded in whatever way they felt. The data collection period ran from the 8<sup>th</sup> of June 2010 until the 21<sup>st</sup> of August 2010.

### 3.7 Data analysis

The participants' responses to the questions were analysed and similar responses with the same general meaning, even if worded differently, were collated into broader categories. The responses were then entered into Microsoft Excel™ before initial statistical organisation and analysis was undertaken. The Excel™ analysis was then followed by more sophisticated statistical analysis using SPSS 17 (2010).

Common responses were drawn out, collated and discussed before statistical analysis allowed a determination of factors that were statistically significant. Statistical significance t-tests and chi-squared tests were used to determine statistical significance. The level of significance used during statistical analysis was  $p < 0.05$ .

### **3.8 Methodology summary**

There are two separate research projects:

The first research project involves database analysis to determine the eco-n™ usage rates and patterns. For the first project the research area is divided into Upper, Central and Lower South Island (Figure 3.1).

The second research project involves analysing the information gathered from interviews with 108 dairy farmers from Canterbury, Otago and Southland. For the second project the research area is divided into 'Zone 1' and 'Zone 2' (Figure 3.2).

### **3.9 Ethics & Confidentiality**

This research project was granted ethics approval by the Lincoln University Human Ethics Committee on the 25<sup>th</sup> of May, 2010 (See Appendix A).

Farmers' confidentiality is assured by the use of a coding system that was used to identify the farmers. The codes are related to the stratified group that the farmer falls into and the farmer's position in their stratified group. The direct link between the farmers and their code numbers has not been published and is solely the knowledge of the author. Neither the supervisors of this research nor Ravensdown will be able to identify any single respondent's responses. All documentation relating to this research will be safely kept for a period of six years, at which time it will be destroyed.

# Chapter 4

## Results

### 4.1 Research Question 1 - What are the patterns of eco-n™ usage?

Determining the eco-n™ usage patterns, while originally thought to be a preliminary function of the eco-n™ research, uncovered different usage rates between the different sub-groups.

Table 4.1 Eco-n™ usage patterns

	Location	# of clients	2009-Users	Churners	Non-users	2008-Users
Upper	<b>Banks Peninsula</b>	167	6%	26%	68%	20%
South	<b>North-Cant</b>	52	10%	38%	52%	21%
Island	<b>Rang/Amb/Ox</b>	78	4%	23%	73%	10%
Standard	<b>Sheff/Darfield</b>	60	8%	15%	77%	8%
Central	<b>Mid-Cant</b>	219	4%	23%	73%	13%
South	<b>North-Otago</b>	94	7%	30%	63%	24%
Island	<b>South-Cant</b>	49	4%	14%	82%	10%
Standard	<b>Ashburton</b>	82	6%	23%	71%	18%
	<b>North-O / South-C</b>	54	4%	33%	63%	33%
	<b>Western S/land</b>	262	2%	15%	84%	7%
Lower	<b>Central Otago</b>	7	0%	14%	86%	0%
South	<b>Western S/land</b>	114	6%	13%	81%	8%
Island	<b>South Otago</b>	129	9%	20%	71%	16%
Standard	<b>Eastern S/land</b>	196	3%	9%	88%	5%
	<b>Otago / S/land</b>	140	1%	14%	85%	4%
	<b>West Otago</b>	98	6%	6%	88%	7%
USI Key	<b>Canterbury</b>	87	21%	39%	40%	48%
CSI Key	<b>Canterbury</b>	215	14%	38%	48%	38%
LSI Key	<b>Otago</b>	199	16%	28%	57%	38%

The table shows the area and the account type in the first column and the more specific location in the second column. The total number of clients in each group is presented in the third column before the percentage of 2009-Users, Churners and Non-users is displayed. The column on the right shows the 2008 user percentage.

There is a large amount of variability in the usage rates from the different groups. Sub-groups ranged from 48% use to no recorded eco-n™ use.

Figure 4.1 displays the Standard Accounts (S) and the Key Accounts (K) and usage of eco-n™ over the three areas - Upper South Island (USI), Central South Island (CSI) & Lower South Island (LSI).

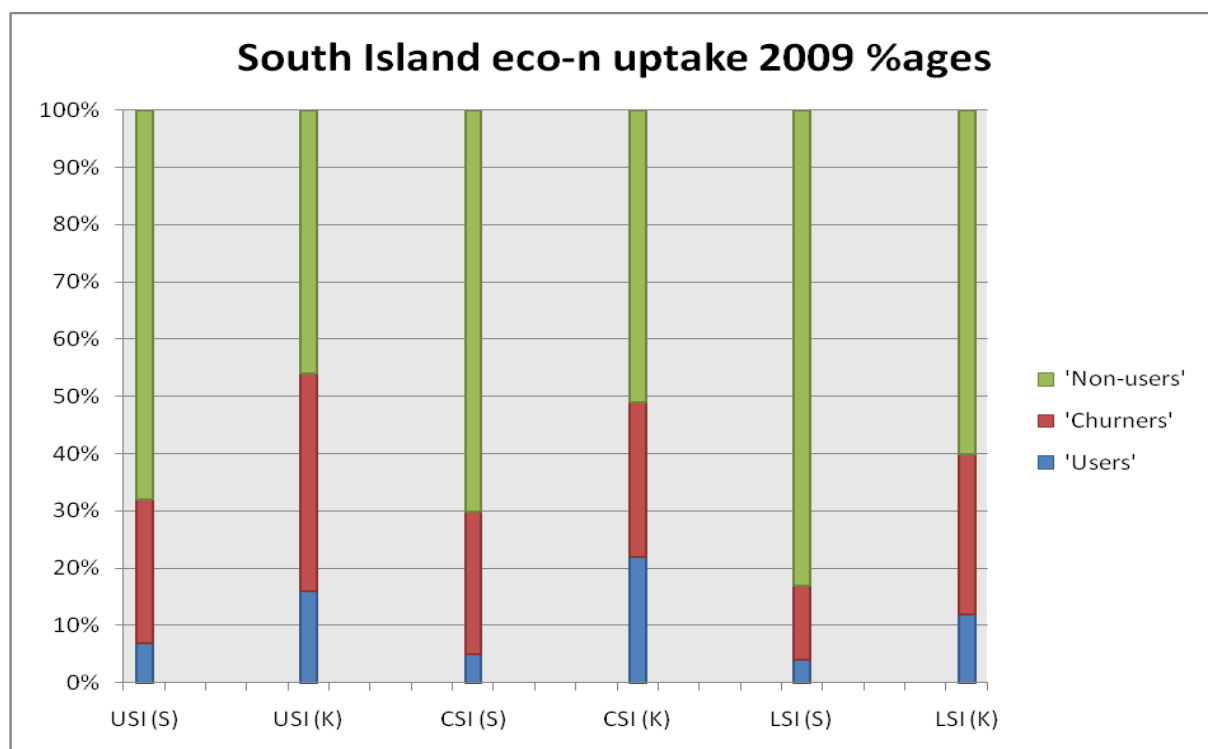


Figure 4.1 South Island eco-n™ usage 2009 % (S=Standard Account, K=Key Account)

A graph of the uptake percentages shows a pattern of both account types decreasing left to right.

From the analysis, Table 4.1 and Figure 4.1, three distinct patterns of eco-n™ usage have emerged:

The first pattern is a reduction in eco-n™ usage across all sub-groups between 2008 & 2009 (i.e. a negative rate of uptake). The average usage rate over the entire research area was 17% in 2008 and 7% in 2009.

The second pattern is that the Key Accounts (users of more than 425 tonne annual fertiliser) had a consistently higher eco-n™ use percentage than the Standard Accounts, but also showed a drop from 2008 to 2009 (Table 4.2).

Table 4.2 Standard and Key Account use 2008 & 2009

	2008	2009
Key Accounts eco-n™ usage rate	41%	17%
Standard Accounts eco-n™ usage rate	12%	5%

As well, Table 4.3 shows that Key Accounts used eco-n™ on a smaller portion of their farm, therefore one driver of adoption may be that larger scale farmers using eco-n™ can trial eco-n™ on a smaller proportion of their farmed land, thereby reducing the perceived risk (Table 4.3):

*Table 4.3 Average eco-n™ use (2009) as a proportion of total farm area*

	<b>Zone 1 Standard</b>	<b>Zone 2 Standard</b>	<b>Zone 1 Key</b>	<b>Zone 2 Key</b>
<b>Percent of farm</b>	82%	70%	37%	50%

The third pattern to emerge from the usage analysis demonstrated a consistently higher usage rate in the Upper South Island and Central South Island account holders when compared to those of the Lower South Island.

*Table 4.4 Eco-n™ usage in relation to broad location, 2008 & 2009*

	<b>2008</b>	<b>2009</b>
Upper South Island usage rate	21%	10%
Central South Island usage rate	23%	8%
Lower South Island usage rate	10%	5%

Although beyond the scope of this research, there are a variety of factors that could lead to the usage of eco-n™ being higher in Canterbury and North Otago than in South Otago and Southland. Possible reasons for this phenomenon range from their proximity to the Lincoln University demonstration farm to irrigation to cashflow, soils and climate.

## **4.2 Research Questions 2 & 3 - What is limiting the uptake of eco-n™ and what elements contribute to farmer decision making regarding eco-n™?**

The usage of eco-n™ has been less than expected by Ravensdown who have a short term goal of a 25% usage rate among their South Island dairy clients (Morris, 2010). The long term goal of Ravensdown is to have 50% of the total area farmed by their South Island dairy clients using eco-n™ (Morris, 2010). This section will identify some of the factors influencing this restricted use.

Table 4.5 presents the demographics of the interview farms. There was a significant difference in rainfall for the Churners and there was a significant difference in experience for the Non-users.

Table 4.5 Farmer Descriptions

	Average Age	Average Experience	Tertiary Education	Annual N Application	Annual MS Production	Herd Size	MS/Hd	Annual Rainfall	Wintering on (%)
<b>2009-User</b>	45	21 years	25%	140 kg	360,000kg/MS	840 hd	428 kg	645mm	33
<b>Churner</b>	44	19 years	19%	144 kg	378,000kg/MS	894 hd	423kg	699mm*	30
<b>Non-user</b>	43	15 years*	19%	129 kg	352,000kg/MS	836 hd	420 kg	652mm	27

(\*) = Statistically significant difference at  $p < 0.05$ .

The decision making structure was analysed over the three different categories (Figure 4.2):

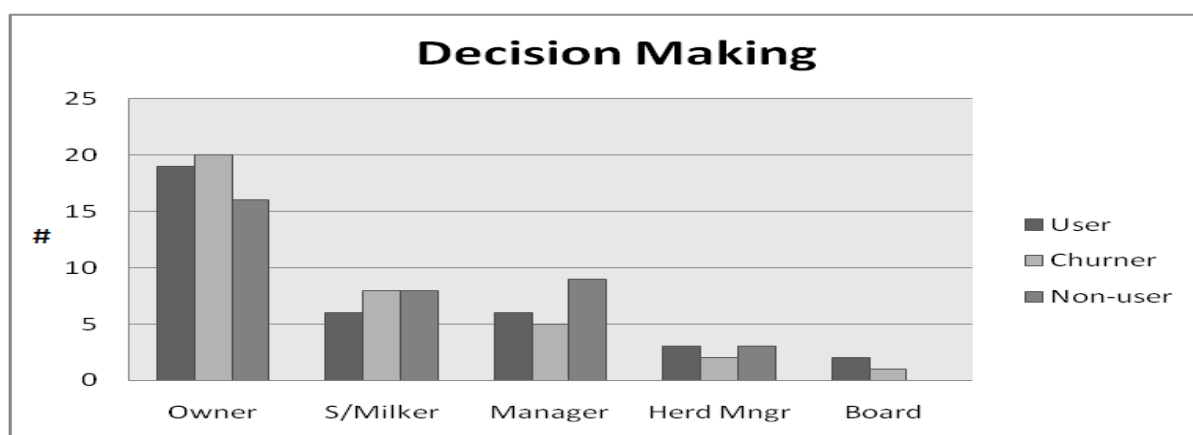


Figure 4.2 Decision making situation in relation to eco-n™ use

The analysis and Figure 4.2 show that there is no statistically significant relationship between the decision making situation and the decision to adopt eco-n™. There were a higher number of managers in the Non-user group but this difference is statistically non-significant.

The basic soil type was analysed over the three different categories (Figure 4.3):

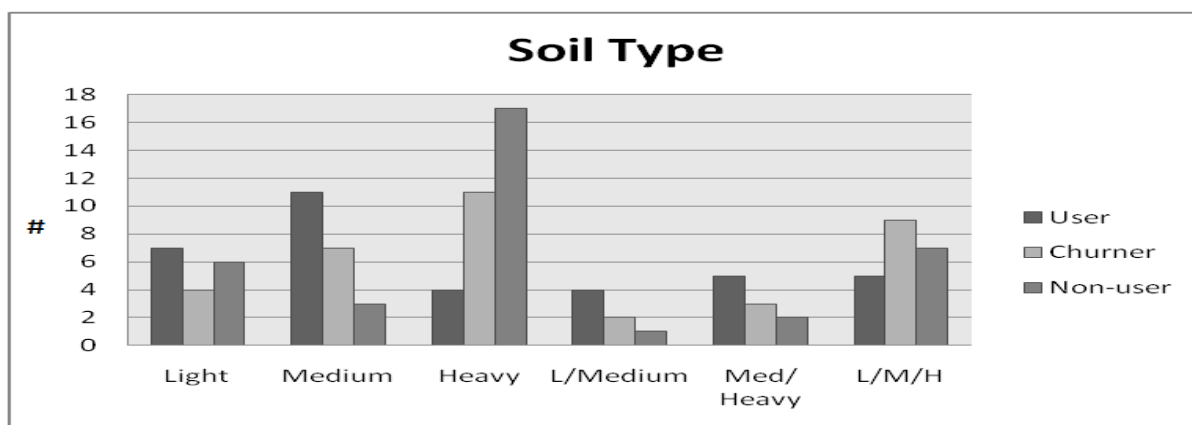


Figure 4.3 Soil type and eco-n™ use

There is a significant difference, at  $p < 0.05$ , between the 2009-Users and Non-users in regard to medium and heavy soils. There are more Non-users on heavier soils and the 2009-Users have significantly more medium soils.

#### 4.2.2 Why do some farmers choose not to use eco-n™?

To determine why some farmers did not use eco-n™, Non-users were questioned. The eight most common responses can be seen in table 4.6:

Table 4.6

	Zone 1 %	Zone 2 %	Average %
1. Do not believe in the production increase	39	61	50
2. Do not believe it is economically beneficial	56	44	50
3. Do not believe the science behind eco-n™	44	50	47
4. Believe the investment is too risky	56	39	47
5. Believe eco-n™ has no effect / does not work	50	28	39
6. Application related issues	17	22	19
7. Do not know enough about eco-n™	17	11	14
8. There are other ways to protect the environment	6	22	14

It is evident that the factors surrounding non-use of eco-n™ are all based on uncertainty over the production responses and disbelief in the science. A total of 30 out of 36 respondents (83%) gave one or more of responses 1 – 5 which are all responses that indicate an element of disbelief. Approximately half of the respondents did not believe in the production benefits, which lends itself to the uncertainty around economic benefits and the risk level of the investment. Although these respondents have never used eco-n™ some 19% of them indicated application related issues as one of the barriers to eco-n™ use. These issues included the

requirement to use a Ravensdown appointed applicator, the restrictions on self application and the necessary but inconvenient timing and method of application.

Only 14% of the Non-users claimed that they do not know enough about eco-n™ to make a sound use decision. There are farmers who have a high level of education about eco-n™ but still do not believe the science or do not believe in the potential benefits.

In Zone 1 6% of Non-users believe there are better ways to protect the environment while 22% of the Non-users in Zone 2 gave this response.

#### 4.2.3 Why do farmers choose to use eco-n™?

The 2009-Users and the Churners were able to give multiple reasons for eco-n™ use and the following is a summary of the six prominent reasons given:

Table 4.7

	2009-Users %	Churners %	Average %
1. The Account Managers' influence	69	67	68
2. For the environmental benefits	61	36*	49
3. To increase production	47	44	46
4. Influenced by other dairy farmers	31	58*	44
5. To use less nitrogen fertiliser	44	28*	36
6. Influenced at field days	14	22	18

(\*) = Statistically significant difference at  $p < 0.05$  between 2009-Users and the Churners.

The results show that the two groups are similarly influenced by the Ravensdown Account Manager and also share the same level of desire to increase production through eco-n™. However, the 2009-Users are statistically more likely (at  $p < 0.05$ ) to use eco-n™ for the environmental benefits and this would provide an incentive to keep using eco-n™ even if the economic benefits are not immediately obvious or observable. The fact that 2009-Users are more likely to use eco-n™ for environmental reasons aligns with the result that the 2009-Users are statistically more likely to have adopted eco-n™ in an attempt to use less nitrogen fertiliser.

Statistical analysis also confirmed that the Churners are more influenced by other dairy farmers and, as the literature review suggests, this is likely to result in inaccurate information and the

portrayal of exaggerated results. This may be why some of the Churners discontinued use as they weren't getting the benefits articulated by their (non-Ravensdown employee) informants. The difference in the amount of influence from other dairy farmers is statistically significant  $p < 0.05$ .

#### 4.2.4 What were the results from farmers' use of eco-n™?

When 2009-Users and the Churners in each zone were asked about the results of using eco-n™ the following results were obtained.

Table 4.8

	2009-Users %	Churners%	Average %
There was some form of visual response	77	26*	53
The response was hard to define	50	36	43
Used less N fertiliser	36	11*	24
There was a measured production increase	25	0	13
Visually appeared to be less frost damage	22	6*	14
No measured response	22	27	26
Created cashflow problems / price	11	44*	29
Did not work / did not do anything / no visual	0	44*	19
Some form of application problem	11	36*	22
Better N fertiliser response	14	11	13
Challenge handling surplus	17	3	10

(\*) = Indicates statistical significance between 2009 Users and the Churners at  $p < 0.05$

The results show that the most common effect of eco-n™ use, for the 2009-Users, was that it created some sort of visual pasture response while a quarter measured an increase in pasture or milk production.

A further result was that 22% of the 2009-Users claimed that their pastures appeared to be less frost damaged in winter. This result was more likely to be experienced by the 2009-Users than the Churners. This result is consistent with the statement by Cameron (personal communication, 2010) "eco-n retains more nitrogen in the soil which enables the plant to take up a higher concentration of ammonium; which in turn increases the solution concentration within the plant. The higher solution concentration of ammonium provides the frost protection".

For the Churners the most common result from eco-n™ use was a negative effect on cashflow as well as a feeling that eco-n™ did not work. A third of the Churners commented on some form of application problem or concern indicating that the current application arrangement plays a role in the discontinued use of eco-n™.

While 44% of 2009-Users used eco-n™ to use less nitrogen fertiliser (Table 4.7), 36% of 2009-Users achieved this (Table 4.8). There were 28% of Churners who used eco-n™ to use less nitrogen fertiliser, 11% of Churners achieved this. The remaining 2009-Users and the remaining Churners commented that pasture responded better to urea after using eco-n™ and instead increased their urea application to maximise the eco-n™ benefits.

Both groups also commented to a similar degree that the response from eco-n™ is hard to define. This means that the 2009-Users and the Churners are having difficulty quantifying the benefits of eco-n™ use.

#### 4.2.5 Will you continue / will you begin to use eco-n™?

Table 4.9

	2009-Users %	Churners %	Non-users %
1. Yes if it increases production	69	39 <sup>a</sup>	38 <sup>a</sup>
2. Yes if economics 'stack up'	24 <sup>a</sup>	45	25 <sup>a</sup>
3. Yes because of environmental benefits	58	6 <sup>a</sup>	0 <sup>a</sup>
4. No if economics do not 'stack up'	31 <sup>a</sup>	28 <sup>a</sup>	3
5. No	0	14 <sup>a</sup>	33 <sup>a</sup>

<sup>(a)</sup> = Numbers within rows without a common letter are significantly different @p<0.05.

The results show that 2009-Users will continue to use eco-n™ if it increases production and also because of the environmental benefits.

While the 2009-Users are statistically more likely to continue use because of environmental reasons, a third of the 2009-Users still commented that they would discontinue use if it becomes apparent that the economics of eco-n™ use do not 'stack up', with a similar number of Churners also giving this response.

Churners will reuse eco-n™ if it can be shown to increase production and hence the economics 'stack up'. The Churners are significantly less likely to reuse eco-n™ for the environmental benefits.

#### 4.2.6 Other comments about eco-n™

When asked to make further comments on eco-n™, the following results were obtained from the interviewees.

Table 4.10

	2009-Users %	Churners %	Non-users %
1. Need site specific results and proof	19*	36*	58*
2. Application needs to be improved	0	6	17
3. Need the option of self application	0	8	11
4. Eco-n™ should be subsidised	3	6	8
5. Up-front costs put strain on cashflow	0	8	0

(\*) = Statistically significant difference at  $p < 0.05$  between 2009-Users, Churners and Non-users.

It should be noted that not all respondents gave answers to the question 'other comments about eco-n™'. Of the answers given the overriding comment that farmers made was that there needs to be some proof or site-specific results to reduce the uncertainty around eco-n™. This comment was made by 38% of the total participants (41 out of 108). However, only 52 farmers gave an answer to the question 'other comments about eco-n™'. Given only 52 responded and 41 gave the answer 'need proof', this equates to 79% of those who responded to this question. As eluded to in section 4.2.2, there were 17% of Non-users who commented that application needs to be improved and 11% who said there needs to be the option of self application.

#### 4.3 Research question 4 – How successful is the diffusion of eco-n™ information

There is a large degree of successful diffusion of eco-n™ information. Every farmer in the research project had at least heard of eco-n™ and had some level of knowledge about how eco-n™ works. There were no 2009-Users or Churners who claimed to not have enough knowledge about eco-n™ to make a sound use decision.

Only 13.9% of the Non-users claimed they did not know enough about eco-n™ to make a sound use decision. Therefore over 85% of the Non-users have received sufficient eco-n™ information and have enough knowledge to make decisions about eco-n™ use. The Non-users account for 33% of the sample so less than 5% of the sample claim to not know enough about eco-n™.

# Chapter 5

## Discussion & Conclusions

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### 5.1 Discussion

#### 5.1.1 What are the patterns of eco-n™ usage?

The eco-n™ usage rate varies considerably between the sub-groups shown in Table 4.1. Variations between sub-groups may be affected by differences in climate, soil type, location, farmer characteristics, farm size and farming system.

There was a reduction in the 2009 usage rates, for all sub-groups, in comparison to the 2008 usage rates. There are a range of factors that may contribute to this but the most prominent relationship identified is the similarly large drop in the Fonterra milk price. This suggests that dairy farmers were in a position of restricted cashflow throughout this period and began reducing expenditure. This may indicate that many of the Churner farmers saw eco-n™ as a discretionary expenditure item.

There is a consistently higher usage rate across the Key Accounts and this aligns with Walton et al. (2008) and Scheuing (1989) who both concluded, in Section 2.4, that technology adoption is more likely to happen on larger farms. There are numerous other possible drivers of this trend in usage patterns and Rogers (1962, p.316) identifies the change agent as one of the major drivers. He goes on to say “the biggest driver of change agent success is the effort he or she expends in communicating information to and liaising with clients”.

The Ravensdown Key Account Managers have been promoted from Standard Account Managers based on their performance. It can be generalised that Key Account Managers are the most successful Account Managers at Ravensdown. In addition, Key Account Managers have less clients to serve so can potentially offer a superior level of service, thereby achieving a higher level of sales. Ravensdown have a goal of achieving 50% usage by land area, not by client number. This may mean that Ravensdown are expending more effort convincing large dairy farms to adopt eco-n™, thereby resulting in a higher usage in the Key Accounts (larger farms).

There is also an unexplained higher usage in the sub-groups closest to and within Canterbury.

### **5.1.2 What elements contribute to farmers' decision making criteria regarding eco-n™?**

The results show a range of elements contributing to farmer decision making regarding eco-n™.

The 2009-Users and the Churners are statistically more likely to have more dairy farming experience than the Non-users. This aligns with the result that the Non-users are more likely to have managers in eco-n™ decision making roles.

Soil type and annual rainfall appear to affect decisions as the 2009-Users are more likely to be on medium soils and the Non-users are more likely to be on heavy soils. The Churners are more likely to have higher annual rainfall than the 2009-Users and the Non-users.

All farmers who have used eco-n™ have been largely influenced by the Ravensdown Account Managers and less so by other dairy farmers. This aligns with Rogers (1962), in Section 2.5, who said the change agent is one of the biggest drivers of the diffusion of innovations. This result also aligns with Fairgray (1979), in Section 2.4, who classified agricultural diffusion into two main stages. The first stage is a small localised diffusion restricted to those who have direct and regular contact with extension officers. The second stage is a low intensity, indirect spread of influence, with knowledge and attitudes below the threshold levels of intensity needed for rapid adoption.

Farmers have adopted eco-n™ for the production benefits and the environmental benefits. Those who continue to use eco-n™ are significantly more likely to have adopted the product for its environmental benefits, including less nitrogen fertiliser use.

There have been varying results from eco-n™ use which adds to farmer decision making. Within the 2009-Users some 78% of farmers have seen some form of visual pasture response while only 28% of the Churner group saw some form of visual pasture response.

It can be assumed that 100% of farmers who used eco-n™ for the environmental benefits will have had the benefit of the intrinsic reward of a good feeling for doing something good for the environment.

Another identified driver of eco-n™ decision making is the inability to quantify the on-farm benefits. This driver is supported by the result that 43% of those who have used eco-n™ commented that the results were hard to define. Lionberger (1960), in Section 2.3, said the adoption decision making process may be re-started after an innovation has been adopted, this

supports the notion of the 'churn' in eco-n™ use and shows that farmers who adopted the technology used the results as a further decision making basis. Lionberger (1960) also claimed the two influential drivers of decision intensity are 1) the cost of adopting the innovation, and 2) the nature of the change. In agreement with Lionberger (1960) the research has shown that the cost elements mentioned and the scientific nature of eco-n™ are the elements that contribute to farmer decision making criteria in regard to eco-n™.

### **5.1.3 What is limiting the uptake of eco-n™?**

The Churners are significantly more likely to have experienced cashflow or price issues in relation to eco-n™ use. This result leads on to the fact that Churners indicated that they would consider re-using eco-n™ if the economics or the cost changed favourably or became apparent. In addition, the Churners are significantly more likely to have experienced or perceived some form of application problem from their use of eco-n™. The Churners are also significantly more likely to desire site-specific results (decreasing financial uncertainty) and proof before further eco-n™ use.

The Non-users chose not to use eco-n™ for reasons of uncertainty and disbelief. A total of 83% of Non-users indicated that the reasons for non-use of eco-n™ were due to a disbelief in eco-n™'s proposed production, environmental and economic benefits. A small group of Non-users also indicated application related issues as a barrier to eco-n™ uptake.

In Section 2.3, Scheuing (1989) identified the five types of adoption risk as financial, functional, physical, psychological and social. It is proposed that eco-n™ only poses a financial and functional risk so it can be assumed that these two risks are influencing the 'limited' uptake of eco-n™. The result can also be related to Lionberger (1960) in section 2.3, who said If the technology use requires major changes that will create a sunk cost if the technology use is discontinued then the risk around adoption is increased (Lionberger, 1960). Rogers (1962) in section 2.3, also said a major factor that may increase or mitigate the identified risks involved with technology is the costs involved in reversion. If the technology can be trialled and then rejected at no great costs then the risk around adoption is reduced. The comments of Lionberger (1960), Rogers (1962) and Scheuing (1989) indicate that there is a low risk of adopting eco-n™. The few risks identified do, however, influence farmer decision making in regard to eco-n™.

#### **5.1.4 How effective is the diffusion of information about eco-n™?**

The research has shown the diffusion of eco-n™ information has been successful as every farmer in the research project had at least heard of eco-n™ and had some level of knowledge about how eco-n™ works. Over 95% of the sample claimed to have enough information and knowledge about eco-n™ to make a sound use decision. Only 13.9% of the Non-users claimed they did not know enough about eco-n™ to make a sound use decision, this is equivalent to 4.6% of the sample.

Historical studies have shown that items such as geographical distribution, cultural differences and language barriers are the major factors that cause problems in the diffusion of information (Falcon, 1981). However, due to the nature of New Zealand dairy farming and the structure of Ravensdown, these issues actually pose minimal barriers to the successful diffusion of eco-n™ information.

## **5.2 Recommendations**

The completion of statistical analysis, the analysis of the results and the collation of individual responses has allowed for the development of some recommendations for Ravensdown to increase eco-n™ understanding, reduce eco-n™ uncertainty and ultimately increase eco-n™ usage.

Ravensdown has a significant amount of competency in the eco-n™ business development role and greater expertise than those of the author. These recommendations simply aim to broaden the scope of potential ideas to increase eco-n™ usage.

### **5.2.1Eco-n™ trial paddocks**

While the Churners have to some level trialled eco-n™ and used their results to come to the decision to discontinue use, there are still a large number of farmers in the Non-user group who can be influenced to trial eco-n™. The total number of Non-users in the research area is 1634 compared to 162 2009-Users. If 10% of the Non-users can be convinced to trial eco-n™, this would be equivalent to the amount of 2009 users.

A reduction in uncertainty may convince Non-users to trial eco-n™. Rather than attempting to convince these Non-users to adopt eco-n™ on a large scale, they should be convinced to trial the product on a very small scale. Ravensdown's Account Managers could try to convince Non-users to do a single half-paddock trial on a representative paddock, an area of 2 - 4 ha. The farmers can then witness the visual response of eco-n™ for a cost of \$300 to \$600.

Although only 53% of farmers claimed to have seen a visual response from eco-n™, there may be other factors affecting this seemingly low percentage. If the entire farm was done, or a selection of entire paddocks it may be hard to see any visual response comparison. Applying eco-n™ to a single half-paddock will allow for an easier evaluation of the presence of a visual response. Ravensdown then need to find a way of assuring the farmers that the visual response amounts to >\$158 worth of milksolids per hectare (the cost of eco-n™).

Eco-n™ literature suggests a 23% increase in dry matter production, which should easily translate to >\$158 of milksolids. The farmers need certainty that this will happen on their farm under their management system. A general basic model can display the required amount of dry matter (Table 5.1):

*Table 5.1 Two methods of calculations for required DM increase per hectare for eco-n™ profitability*

Required Profit Increase		\$158.00
Profit per kg MS	‘say’	\$3.00
(Over Farm Working Expenses)		
Required MS increase		53kg
Kg MS per Kg DM (Intelect.co.nz)		0.085
Required increase in DM		624kg

Required Profit Increase		\$ 158.00
\$ value of 1kg of DM	‘say’	0.25
Required DM increase		632kg

- At an average production of 14,000kg/dm/ha a 630kg/dm/ha increase would be equivalent to 5%.

A large proportion of interviewed farmers would be happy for trials to be carried out on their property as they have a desire for site specific results. If it was 'half paddock free' or 'free 4ha trial plot' (for example) most farmers would choose to trial one paddock. The downside of this type of promotion is that it may cause conflict with Ravensdown's other (non-dairy farmer) shareholders. It can also be noted that there were farmers interviewed who did not measure pasture but who would be willing to pay for a comprehensive pasture measurement, management and feed budgeting service. This activity may complement Ravensdown's nutrition services.

### **5.2.2 Applicators**

There have been various comments made regarding the application of eco-n™. Some farmers desire the option to either apply the product themselves, or to have their regular chemical applicator apply the product. This is restricting the uptake of eco-n™ in some cases and Ravensdown may consider options for reducing this barrier. Ravensdown give the following reasons why only approved applicators can apply eco-n™:

- They adhere to the eco-n™ best practice application guidelines
- They have GPS navigation and a precise positioning tool
- The sprayer set up meets the requirements for precise eco-n™ placement
- They follow administration procedures

### **5.2.3 Further suggestions for Ravensdown**

Farmers need proof that eco-n™ is effective, in both an economic and environmental sense, across a range of environments, districts, soil types and climates (site-specific results). Farmers need certainty that they will receive an economic increase in pasture production from the use of eco-n™. A proposal of such an idea can be found in Appendix D. The idea in Appendix D, however, only portrays a visual response and, as mentioned, farmers require certainty that any visual response will transpire into an economic benefit.

### **5.2.4 Advertising**

The results indicated successful diffusion of eco-n™ information. Therefore increasing expenditure on eco-n™ awareness (advertising) will likely not result in increased usage as the majority of the population claim to have sufficient information to make a sound use decision. However, in contrast to this point there is a risk that farmers will stop considering eco-n™ use if they do not see eco-n™ advertised. There needs to be continued awareness to maintain farmer thought about eco-n™.

### **5.2.5 Reasons for use**

Farmers who adopt eco-n™ for the production benefits can likely have a way of measuring the presence of that benefit, even if only by eye. Those who adopt eco-n™ for the environmental benefit have no way of measuring the benefit and can only use published research results to gauge whether or not they are receiving the environmental benefit. In light of this Ravensdown could attempt to identify and target farmers who exhibit environmental awareness.

### **5.2.6 Summary of recommendations**

1. Ensure dairy farmers have a thorough understanding of eco-n™, the production and environmental benefits and the factors that affect their variability.
2. Give farmers as much proof as possible that they will receive the proposed benefits of eco-n™ use.
3. Ensure users of eco-n™ are aware of all the potential benefits of eco-n™ and have the opportunity and ability to identify and measure as many of these benefits as possible.
4. Ensure the farmers have as much information as possible to make an economic calculation on eco-n™ use.
5. Target larger farms located in Canterbury and North Otago
6. Mentoring of Standard Account Managers by Key Account Managers.
7. On-farm trials and site specific results would be helpful for both Churners and Non-users.
8. Allow farmers to apply their own eco-n™ or to use their regular chemical applicator.
9. Establish frost protection benefits.
10. More emphasis on target marketing according to farmer traits – environmental stratification, economic stratification.
11. Farmers understand the product, but advertising is necessary to keep the product in farmers' thoughts.

## 5.3 Conclusion

The sociology of the New Zealand dairy farming industry consists of a large proportion of farmers who want to continue to increase production but who also have an ever-growing consideration for the environment they live and farm in.

Scientific research suggests that eco-n™ aligns with the needs and wants of New Zealand dairy farmers but there are a range of factors limiting the widespread adoption of eco-n™.

There was a substantial reduction in the amount of eco-n™ use from 2008 to 2009, this reduction correlates with the reduction in the Fonterra payout price over the same period.

More Key Account holders use eco-n™ than Standard Account holders. More Canterbury and North Otago dairy farmers use eco-n™ than Southland and South Otago dairy farmers.

This research has found that eco-n™ has different levels of applicability to different clients. The variation in applicability is a result of a differing climate, soil type, location, farm size and farming system.

The research has shown that all of the respondents had some basic knowledge of eco-n™ and 95% of the respondents claimed to have an understanding of how eco-n™ works. The diffusion of eco-n™ information has been successfully performed by Ravensdown Account Managers, less so by word-of-mouth, and least of all by the other methods mentioned in Section 1.5 such as the Ravensdown and LUDF websites, advertising and publications, field days and independent farm management consultants.

Some 69% of 2009-Users and 67% of Churners claim to have been influenced to use eco-n™ by their Account Manager. Some 31% of the 2009-Users and 58% of Churners also indicated they were influenced by an element of word-of-mouth between dairy farmers. The significant difference is that the Churners are more likely to have been influenced by other dairy farmers who have already used eco-n™. This result means Churners may have adopted eco-n™ expecting the same results as those dairy farmers who influenced them.

Some dairy farmers use eco-n™ to increase production and to protect the environment, including decreasing their annual quantity of nitrogen fertiliser application. The continued users of eco-n™ are statistically more likely to have chosen to use eco-n™ for its environmental

benefits and to use less nitrogen fertiliser, however, these farmers still have a desire to increase production. The Churners are statistically more likely to have chosen to use eco-n™ for the production benefits alone.

The most common result that 2009-Users have experienced from eco-n™ use is that it produces some form of visual pasture response, either through a 'greening' of the pasture, increased pasture production, or a healthier looking pasture with less frost damage than expected. Some 77% of 2009-Users indicated one of these results.

The most common result that the Churners have experienced from eco-n™ use is that it has a negative effect on cashflow not only because of the up-front costs but because any benefits will also take a long time to flow through into the cashflow and because the benefits are hard to define. Some 45% of the Churners commented that this is a negative. This result also aligns with the identification of a strong correlation between eco-n™ use and the Fonterra payout. There was a similar proportion of Churners who felt that eco-n™ did not work and that there were no effects or benefits from using the product. A third of the Churners also indicated some form of application problem or issue as a reason for discontinuing use.

The reasons Non-users gave for not using eco-n™ were mostly in relation to a disbelief in eco-n™'s proposed benefits as well as economic factors like price, profitability and cashflow. The Non-users also indicated application restrictions as a barrier to eco-n™ use.

There is a range of activities Ravensdown can undertake to ensure the 2009-Users of eco-n™ continue to use the product and continue to view eco-n™ as a necessary farming input. There are a range of options that Ravensdown have for reducing the uncertainty faced by the Churners use of eco-n™. There are also options for reducing the causes for Non-use as indicated by the Non-users.

The mixed research method of qualitative and quantitative disciplines was appropriate for this project and allowed for an understanding of the factors affecting eco-n™ uptake in relation to the contextual surroundings of the farm and the farmer.

## 5.4 Further Research

### Scientific Research

- Research regarding eco-n™'s frost protection potential including the potential increase in pasture production from non-damaged plants.
- Research that quantifies the variability in eco-n™'s benefits in relation to the climate / annual rainfall in a particular season. “Last year was a bad year to use eco-n™ but this year I would have got a lot more benefit from it” Respondent, Group 5, 2010.
- Research that quantifies the 23% pasture increase. How applicable is this figure to various farms, what is the variability in this figure? and what factors cause the variability?
- How can the reduction in greenhouse gas emissions, or the reduction in nitrate leaching loss, produced by using eco-n™ be better ‘recognised’ and thus be used to provide an incentive for farmer uptake?
- How effective is eco-n™ in reducing the environmental impacts of ‘winter run-off blocks’.
- A sensitivity analysis of returns at varying pasture response rates and milk prices.
- Development of a comprehensive model to demonstrate best-practice for eco-n™ over a range of farms and areas.
- How can eco-n™ be used strategically with urea to maximise farmer benefits?

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# **Appendices**

## Appendix A

Research and Commercialisation Office



New Zealand's specialist land-based university

T 64 3 325 3838

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PO Box 84, Lincoln University

**Application No:** 2010-13

25 May 2010

**Title:** Diffusion and adoption of Eco-N

**Applicants:** Daniel Smith

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*The Lincoln University Human Ethics Committee has reviewed the above noted application.*

Dear Daniel

Thank you for your detailed response to the questions which were forwarded to you on the Committee's behalf.

The issues raised have been satisfactorily addressed with one small amendment. Please include the phone numbers of your Supervisors in the Invitation Letter.

With this amendment, I am pleased to give final approval to your project and may I, on behalf of the Committee, wish you success in your research.

Yours sincerely

Professor Grant Cushman

Chair, Human Ethics Committee

## Appendix B

Daniel Smith

Daniel.smith@lincolnuni.ac.nz

Lincoln University

Date

John Farmer

Dear John,

**RE: Research on the adoption of agricultural technologies**

My name is Daniel Smith. I am a Master of Applied Science student at Lincoln University.

The Master of Applied Science programme requires students to complete a research project. My research interests are related to the innovation and adoption of agricultural technologies.

I have chosen to do my research project on eco-n, the nitrification inhibitor technology marketed by Ravensdown Fertiliser Cooperative.

Given the topical nature of nitrification inhibitors and market uptake of new technologies such as eco-n, I approached Ravensdown to see if they would be interested in, and benefit from, my proposed research project about eco-n.

Ravensdown is supportive of my research proposal and has agreed to fund the costs of the travel involved. Ravensdown believe the results of my research will help them to better serve their shareholders. My research approach involves interviewing dairy farmers from Canterbury, Otago and Southland about eco-n and you have been randomly selected from the applicable Ravensdown database to participate in my research project. Your participation in the project is entirely voluntary. Participation would involve hosting me during a short interview of approximately 20 - 30 minutes.

The research period will be in June and July of this year.

**I will follow this letter with a brief phone call in the next 10 days** to confirm your participation or non-participation. Regardless of your experience with this technology your input is valuable to my research project. I would be very interested in hearing your views over the pros and cons of eco-n.

All information will be treated with the utmost respect and confidentiality.

**Participant's individual responses will not be made available to any person from Ravensdown at any time.** Participants will be identified by code only and responses will not be traceable to any individual.

It is my desire that the research project will return results that can be used to improve the ways that technology and information is made available to farmers.

Daniel Smith

## Appendix C

### Questionnaires

#### Research Questions (Groups 1, 4, 7, 10) 2009-Users

1. Farmer Age ..... Years experience .....  
  
Tertiary education.....
2. Location
3. Farm size .....Ha annual N applied.....
4. Approximate 2008 / 2009 production .....Kg MS .....Hd
5. Approximate 2009 / 2010 production .....Kg MS .....Hd
6. Ownership structure    manager    S/milker    herd manager    .....
7. Soil type                    light    medium    heavy    .....
8. Cows wintered                    Cows                    on    off  
  
   Replacements                    on    off
9. Comments on wintering system
10. Approximate %age of bought-in feed    .....
11. Average annual rainfall .....mm/yr
12. Irrigation                    yes    no                    Type.....Area.....
13. Have you ever used eco-n?

**14. What years did you use eco-n?**

*Did you apply eco-n twice in the years you used it?*

**15. What areas did you apply it to?**

*Size*

*Why these areas?*

**16. Are you using eco-n in 2010? twice?**

**17. What areas are you applying it to?**

*Size*

*Why these areas?*

**18. What were the reasons you decided to use eco-n?**

*Key sources of information?*

*Most influential source?*

**19. What were the results from your use of eco-n?**

**20. Would you use eco-n again? / will you continue to use**

*Why? Why not?*

*Profit v environmental reasons*

**Further Comments?**

*What would cause you to stop using eco-n?*

## Research Questions (Groups 3, 6, 9 & 12) Non-Users

1. Farmer Age .....Years experience .....:  
  
Tertiary education.....:
2. Location
3. Farm size .....Ha annual N applied.....
4. Approximate 2008 / 2009 production .....Kg MS .....Hd
5. Approximate 2009 / 2010 production .....Kg MS .....Hd
6. Ownership structure manager S/milker herd manager .....
7. Soil type light medium heavy .....
8. Cows wintered Cows on off  
Replacements on off
9. Comments on wintering system
10. Approximate %age of bought-in feed .....
11. Average annual rainfall.....mm/yr
12. Irrigation yes no Type.....Area.....
13. Have you ever used eco-n?
14. What were the reasons you decided not to use eco-n?

*Key sources of information?*

*Most influential source?*

**15. Is there anything else you don't like about eco-n?**

*The product / the service / the info / price / etc*

**16. What would it take for you to use eco-n in the future?**

**17. Other comments about eco-n**

## Research Questions (Groups 2, 5, 8 & 11) 'Churners'

1. Farmer Age .....Years experience .....  
  
Tertiary education.....
2. Location
3. Farm size .....Ha annual N applied.....
4. Approximate 2008 / 2009 production .....Kg MS .....Hd
5. Approximate 2009 / 2010 production .....Kg MS .....Hd
6. Ownership structure    manager    S/milker    herd manager    .....
7. Soil type                    light    medium    heavy    ..... .....
8. Cows wintered                    Cows                    on    off  
  
   Replacements                    on    off
9. Comments on wintering system
10. Approximate %age of bought-in feed    .....
11. Average annual rainfall .....mm/yr  
  
Irrigation                    Yes    No    Type.....Area.....
12. Have you ever used eco-n?
14. What years did you use eco-n?
15. Did you apply eco-n twice?
16. What were the reasons you decided to use eco-n?

*Key sources of information?*

*Most influential source?*

**17. What were the reasons you decided to stop using use eco-n?**

*Key sources of information?*

*Most influential source?*

**18. Is there anything else you don't like about eco-n?**

**19. What would it take for you to use eco-n again?**

**21. Other comments about eco-n**

## Appendix D

### Example of marketing idea mentioned in section 6.2

#### Eco-n pasture responses from half-paddock trials



Figure A.C.1 Marketing idea

**Disclaimer:** The images in the above picture were sourced from Google Images and Google Maps and do not portray actual half-paddock responses from eco-n use.

## Appendix E Statistical data

	Description	Mean Group 1	Mean Group 2	Mean Group 3	1 v 2 Sig. 2 - tailed	1 v 3 Sig. 2 - tailed	2 v 3 Sig. 2 - tailed
	General Questions						
	Age	45.36	44.5	43.83	0.681	0.455	44.165
	Experience	21.39	19.89	15.83	0.563	0.036	17.86
	Education	0.25	0.19	0.19	0.577	0.577	0.19
	Annual N	140.42	144.31	129.3	0.720	0.35	136.805
	Production	359729	378131	352827	0.680	0.885	365479
	Herd Size	840.97	894.03	836.88	0.604	0.97	865.455
	MS / Head	426.06	423.05	420.16	0.580	0.315	421.605
	Wintering	0.33	0.31	0.28	0.804	0.615	0.295
	Bought Feed	5.94	5.42	3.56	0.719	0.067	4.49
	Rainfall	645.56	699.86	652.5	0.042	0.759	676.18
	Eco-N Questions						
	Area	160.11	-	-	-	-	-
Why this	Cashflow	0.31	-	-	-	-	-
	Trial	0.31	-	-	-	-	-
	Effluent	0.14	-	-	-	-	-
	Soils	0.19	-	-	-	-	-
	Platform	0.31	-	-	-	-	-
Why?	Years use	2.83	1.72	-	0.000	-	-
	Increase Prod.	0.47	0.44	-	0.816	-	-
	High SR	0.14	0.06	-	0.239	-	-
	Less fert N	0.44	0.28	-	0.145	-	-
	Environment	0.72	0.44	-	0.017	-	-
	AM influence	0.69	0.67	-	0.804	-	-
	LUDF influence	0.14	0.14	-	1.000	-	-
	Field days	0.14	0.22	-	0.365	-	-
	Other farmers	0.31	0.58	-	0.017	-	-
Why not?	Too risky	-	-	0.5	-	-	-
	Dont believe Sci	-	-	0.5	-	-	-
	Dont believe Prod	-	-	0.47	-	-	-
	Other Protection	-	-	0.39	-	-	-
	Economics	-	-	0.19	-	-	-
	Application issue	-	-	0.14	-	-	-
	Dont know enough	-	-	0.14	-	-	-
	Doesnt work	-	-	0.14	-	-	-
Results	Less frost dmg	0.22	0.06	-	0.041	-	-
	Visual response	0.78	0.28	-	0.000	-	-
	Measured response	0.25	0	-	0.001	-	-
	Less fert N	0.36	0.11	-	0.012	-	-
	Feels good	0.11	0.14	-	0.726	-	-
	Better N response	0.14	0.11	-	0.726	-	-
	No attributed dif.	0.39	0.19	-	0.000	-	-
	Didn't work	0	0.39	-	0.071	-	-
	Unaware of result	0.111	0.139	-	0.000	-	-
	Created cash issues	0.14	0.44	-	0.726	-	-
	Can't handle surplus	0.14	0.06	-	0.239	-	-
	Aplication problems	0.08	0.36	-	0.004	-	-
Further U:	Yes Enviro	0.02	0.21	0.018	-	0.656	0.114
	Yes Prod	0.046	0.45	0.038	-	0.401	0.244
	No if \$	0.032	0.2	0.033	-	0.235	0.1165
	Yes if \$	0.02	0.16	0.01	-	0.216	0.085
Other	Self App.	0.04	0.42	0.033	-	0.848	0.2265
	Subsidy	0.0485	0.06	0.0456	-	0.361	0.0528
	Upfront \$	0.023	0.03	0.02	-	0.654	0.025
	Need Proof	0.03	0.07	0.05	-	0.845	0.06

## Appendix F Descriptive Statistics

Descriptive Statistics						
	N	Minimum	Maximum	Sum	Mean	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
AGE	108	28	63	4813	44.56	.852
EXPRNCE	108	2	50	2056	19.04	1.098
ED	108	0	1	23	.21	.040
ANLN	108	0	250	14905	138.01	4.892
PRUD	108	120000	1250000	39264800	363562.96	19315.281
HERD	108	300	3000	92588	857.29	44.812
MSHD	108	375	488	45694	423.09	2.326
WINTER	108	0	1	33	.31	.045
FEEDP	108	0	30	537	4.97	.541
RAIN	108	450	900	71925	665.97	10.209
YEARSUSE	108	0	6	164	1.52	.136
AREA	72	0	500	5764	80.06	13.431
CFLOW	36	0	1	11	.31	.078
TRIAL	36	0	1	11	.31	.078
EFFLNT	36	0	1	5	.14	.058
SOILS	36	0	1	7	.19	.067
PFORM	36	0	1	11	.31	.078
INCPROD	72	0	1	33	.46	.059
HIGHSR	72	0	1	7	.10	.035
LESSFN	72	0	1	26	.36	.057
ENVIRO	72	0	1	42	.58	.059
AMINF	72	0	1	49	.68	.055
LUDFINF	72	0	1	10	.14	.041
FLDAY	72	0	1	13	.18	.046
OTFRMS	72	0	1	32	.44	.059
TRISKY	36	0	1	17	.47	.084
DBSCIE	36	0	1	17	.47	.084
DBPROD	36	0	1	18	.50	.085
POWVERE	36	0	1	5	.14	.058
ECNMCS	36	0	1	18	.50	.085
APPRB	36	0	1	7	.19	.067
DONTNO	36	0	1	5	.14	.058
DSNTWK	36	0	1	14	.39	.082
LFRSTDM	72	0	1	10	.14	.041
VIS	72	0	1	38	.53	.059
Prod / MEAS	72	0	1	9	.13	.039
LESSN	72	0	1	17	.24	.050
FLSGD	72	0	1	9	.13	.039
BNRES	72	0	1	9	.13	.039
CHANGE	72	.00	5.00	92.00	1.2778	.14156
NOATTRIB	72	0	1	21	.29	.054
DDNTWK	72	0	1	14	.19	.047
UNAWARE	108	.00	1.00	9.00	.0833	.02672
CCFPBS	72	0	1	21	.29	.054