Dairy farmers' perspectives of riparian corridor design and management:

A Canterbury, New Zealand, case study

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Riparian corridors provide many functions in agricultural landscapes which contribute to water quality and ecological values. However intensification of dairy farms has degraded waterways and their functions within many regions of New Zealand. Waterways have been left unfenced and accessible to stock, which has led to increased sedimentation and contamination of surface water, and the loss of other riparian functions that rely on vegetation and clean water such as biodiversity, fishing, swimming, food gathering, and recreational activities.

Increasing attention upon these issues both in the media and in public policy, and the perceived need to protect the reputation of the New Zealand dairy industry, has led dairy companies, regional councils and non-governmental organizations to develop voluntary agri-environmental programmes that encourage farmer suppliers of dairy companies to exclude stock from riparian corridors (including from main crossing points) and to progressively plant some of their riparian corridors. There have been surveys of progress towards targets set by these programmes, but little is known about farmers' first hand experiences of the design and management of their riparian corridors.

Through key informant interviews with farmers in a Canterbury case study, this research describes how dairy farmers are designing and managing their riparian corridors, and evaluates their effectiveness for meeting dairy farmer, regulatory and industry expectations.

Keywords: Intensive dairy farming, riparian corridor impacts, riparian corridor protection and restoration, voluntary agri-environmental programme effectiveness

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Chapter 1

Introduction

1.1 Problem Statement

Agricultural intensification, as part of global food production, has been widely recognised as a driver of environmental degradation (Tilman et al., 2002) including water quality decline. As a food exporting bio-economy New Zealand faces particular challenges in managing the environmental effects of agriculture, specifically those due to the intensification of bovine milk production (dairy farming).

Historically, different agricultural practices have been confined to areas with certain soil conditions and water availability. In areas susceptible to low rainfall, drought has limited the stock carrying capacity of the land (MacLeod & Moller, 2006). However developments in technology such as irrigation and an increase in the economic viability of dairy, has enabled expansion and intensification of land use (Britton, 2007; MacLeod & Moller, 2006). This is particularly true in the Canterbury region where dairy has grown rapidly over the last decade (Hill, 2013). The most contested impact of dairy intensification has been upon water quality of both surface and groundwater.

The Resource Management Act (RMA) is the primary legislation concerned with water quality in open waterways. Policy and regulation have often been reactive to water quality issues associated with non-point source pollution due to agriculture, including the entrance of nutrients, pathogens and sediment into surface water systems through the erosion of banks and runoff from adjacent land use (Miller, 2011). Following a successful 'dirty dairying' media campaign by Fish and Game New Zealand, these impacts were brought to the attention of the media (Hughey et al., 2010). The resulting public outcry led to significant pressure on both the government and the industry to change the way farmers manage land with respect to water (Jay & Morad, 2007). Water quality and quantity issues have become a focus of RMA policy, and the Parliamentary Commissioner for the Environment has identified risks to water quality and aquatic habitats in relation to expansion of intensive land use such as dairy (Parliamentary Commissioner for the Environment, 2004, 2015b).

Policy objectives to improve water quality and mitigate the negative impact of agriculture on waterways have now been established at all levels of government. A voluntary approach of agri-environmental programmes has been favoured over regulatory measures (Parliamentary

Commissioner for the Environment, 2004). Public policy and dairy sector initiatives identify riparian corridors as part of the solution. Policy and practice in both the agricultural industry and government have encouraged farmers to create riparian corridors in two ways: through stock exclusion and planting (Miller, 2011). Stock exclusion in particular has been a focus of the dairy sector, and since 2003 when the Dairy and Clean Streams Accord was set out, fencing of riparian corridors has increased significantly on dairy farms (Bewsell et al., 2007; Ministry for Primary Industries, 2013; Sanson & Baxter, 2011). There have been both regional and nationwide surveys that have estimated the extent of riparian stock exclusion and smaller less comprehensive studies that discuss the extent of riparian vegetation; however specific evidence varies due to the method of collection and objectives of each study (Ministry for Primary Industries, 2013; Renouf & Harding, 2015; Sanson & Baxter, 2011). There is less knowledge about farmers' experiences of riparian corridor design and management and the factors that influence success.

Riparian corridors have been well researched in relation to the benefits for water quality which include providing filtering of surface runoff, denitrification, steam shading, reduced soil erosion and loss of nutrients to waterways, and the provision of semi-aquatic and aquatic habitat for indigenous wildlife (Berges, 2009; Burrell et al., 2014; Collier et al., 1995; Fremier et al., 2015; Quinn et al., 2001). It is also now established that fencing to exclude stock and planting can mitigate the impact of pastoral farming on different water quality parameters (Collins et al., 2013; Covalla et al., 2001; Wilcock et al., 2009). Studies have also identified the importance of information, funding and on-farm benefits for rural landowners in encouraging implementation of riparian fencing (Aarons, 2011; Bewsell et al., 2007; Primdahl et al., 2013; Rhodes et al., 2002), and the effectiveness of a voluntary approach to the design and management of riparian areas (Miller, 2011). However there is still a need to better understand the farmer perspective and experience and how this shapes practice.

This thesis uses in-depth interviews with dairy farmers as key informants within Canterbury, New Zealand to determine how these dairy farmers understand the role of riparian corridors and their experience of implementation, and to gain insight into farmers' experience of corridor management after implementation. The study therefore addresses a gap in current knowledge by reporting on a key factor that influences the effectiveness (or otherwise) of policy intended to mitigate the water quality impacts of dairy farming through implementation of specified on-farm practices (as opposed to managing environmental outcomes).

1.2 Research Questions and Objectives

The overall question for the research is: How do dairy farmers experience the design and management of riparian corridors and what are the implications of the findings for better corridor design and management, industry practice, and policy?

The research objectives are outlined below as a way to guide the progression of the thesis.

1. To describe the functions of riparian areas according to scientific literature, and define the current, regulatory and dairy industry riparian planning and management policies and practices that provides the framework for riparian corridors in Canterbury (Chapter 2 & 3).

2. To review current evidence of farmers implementing riparian corridors (Chapter 4).

3. To identify and gain insight into the experiences of farmers in implementing and designing riparian corridors (Chapter 6).

4. To describe the management of riparian areas from a dairy farmers' perspective (Chapter 6).

5. To determine the implications of the results for policy, design and management of riparian corridors in intensive dairy farm landscapes (Chapter 7).

1.3 Research Approach

This research employed an interpretive approach to answer its research questions. An interpretive strategy delivers in-depth information on the problem and provides for an investigation into a problem in which little is known (Davidson & Tolich, 2003). It uses inductive analysis where patterns, themes and categories are built from the bottom up. This section describes the study design, its location, and outlines the methods used.

1.3.1 Research Design

The design of this research is a case study. A case study design allows for "how" and "why" questions to be answered about complex and contextual issues (Yin, 2003 as cited in Baxter & Jack, 2008). It is a strategy of inquiry "in which a researcher explores in-depth a programme, event, activity, process or one or more individuals" (Creswell, 2009, p. 13). The question this research primarily asks is "how do dairy farmers experience the design and management of riparian corridors?" It aims to gain insight into dairy farmer experiences, rather than a broad overview of what is being done. Therefore a case study is the most applicable research design option. While the limitation of this approach is

the restricted ability to formally generalise the findings beyond the context of the specific case, the results nonetheless give an indication of issues that could be the focus of further research, and indicate matters that could usefully be given further consideration in developing industry and public policy.

The study area selected is the Canterbury region which is undergoing dairy intensification and is a landscape with significant water quality issues and where improved management of riparian margins has been widely promoted. Canterbury has different landscapes ranging from foothills to flat lowlands and many of the issues associated with riparian corridors relate to stock management. This research therefore addresses questions and objectives that focus in the first instance on stock exclusion from riparian corridors, but also considers experiences in the restoration and management of riparian vegetation.

Study Area

The Canterbury landscape has changed dramatically over the past 1000 years (Sinton, 2008). Prior to human arrival the Canterbury plains were a multidimensional network of native forest, tussock land and swampy wetlands near to the coast (Renouf & Harding, 2015). After Maori arrival forest was cleared by fire, replacing it with tussock grassland (Environment Canterbury, 2010a). Further deforestation continued after European settlement in the 1840's (Renouf & Harding, 2015), which resulted in many remaining forested areas being, cut and burned to create grazing land (Environment Canterbury, 2010a).

Agriculture became the driving force in landscape change, drainage of swamps and the straightening of rivers on the Canterbury Plains delivered fertile soils and grassland ideal for sheep farming (Renouf & Harding, 2015). Recently the improvement of irrigation technologies has meant that intensity of agricultural practices has increased (MacLeod & Moller, 2006).

Irrigation techniques have developed and now enable the land to be used more intensively with the shift from sheep grazing to dairy farming which has taken off in the last 15 years. The number of sheep declined 20% between 1996 and 2006, and the acceleration of the dairy industry meant that Canterbury changed from being an insignificant dairying region to a major one (Environment Canterbury, 2008). In terms of both area and cow numbers the average South Island dairy farm is larger than in the North Island. North Canterbury and South Canterbury have two of the highest averages of cows per hectare in the country and the average herd size is continuing to increase (Livestock Improvement Corporation & DairyNZ, 2014). Shown in the below Figure (1.1) Canterbury has increased in density of herd sizes across the region.

Figure 1.1 Study area, dairy herd size increase in density across region. 2004-2014 (Environment Canterbury, 2014)

The region has over 78,000 kilometres of waterways from alpine, foothill and lowland spring fed rivers (Environment Canterbury, 2010b). However the often naturally meandering river systems have been replaced by irrigation drains and water races (Renouf & Harding, 2015) and the increasing intensification has resulted in costs to the environment (Tait & Cullen, 2006). The key issues identified for Canterbury streams are nutrient enrichment, faecal contamination, excessive sediment inputs and siltation of river beds (Environment Canterbury, 2010b). The Parliamentary Commissioner for the Environment (2013) claims this will increase as modelling suggests that by 2020 dairy farms will cover over 650,000 hectares more land throughout New Zealand than in 1996 and 70% of this increase will occur in Canterbury.

Within the Canterbury Plains, the potential for soil runoff is low to moderate vulnerability (Webb et al., 2010), however access of stock to waterways and drains is a recognised problem which causes animal induced erosion and faecal contamination. The surface waterbodies of Canterbury are important due to their associated cultural, ecological, and recreational and amenity values and the changes to land use and declining water quality negatively impact on these values (Environment Canterbury, 2011a).

Although the distinct features of Canterbury such as its high agricultural intensity and dependence on irrigation can be seen as limiting the wider application of the findings, Canterbury's water quality issues mean it has become a significant location for a range of initiatives for, and research into, riparian corridors. This makes Canterbury an ideal area in which to study the issues that relate to riparian corridor implementation and management, as there is already a significant knowledge base for this research, and a growing body of practical experience.

1.3.2 Research Method

A qualitative research method was chosen as it gives an in-depth perspective of the individual farmer's experiences (Creswell, 2009). A particular strength of qualitative research is in the flexibility it provides in selecting and accessing informants, and in particular the way it allows for questioning and discussion to expand on answers given by informants during the interviews. This is because the researcher is the instrument for data collection, used to see, hear and understand the (Creswell, 2009). The use of qualitative methods means that data is accumulated through collaboration between the researcher and the informant. It allows for informants to describe their views of reality and the researcher to understand their experience (Baxter & Jack, 2008). Qualitative methods are ideal to answer the questions asked in this research, as they will give an insight into riparian corridor practice on 15 dairy farms from the perspective of land management and the effectiveness for meeting individual dairy farmer, regulatory and industry objectives, and thus help to improve actions associated with riparian corridors.

However there are also limitations, due to the need for a high level of reflexivity on the part of the researcher, and a more in-depth explanation of interview and analysis methods will be given in Chapter 5.

1.3.3 Definition of Terms

This thesis refers to specific terms, listed in order of appearance; these are established and defined below to avoid confusion.

Dairy Farmer – is used throughout the thesis to refer to a person whose occupation is to rear cows and use them for milk production.

Intensification - is defined as an increase of cattle per hectare of land.

Waterway - This research uses the term *waterway* as defined in the Sustainable Dairying: Water Accord in which a waterway is "a lake, spring, river or stream (including streams that have

been artificially straightened but excluding drains) that permanently contains water and any significant wetland. For the avoidance of doubt, this definition does not include ephemeral watercourses that flow during or immediately following extreme weather events" (DELG, 2013, p. 15). Where drains and ephemeral watercourses are included it is specified.

Industry - For the purposes of this thesis *industry* is a term that encompasses the companies that dairy farmers supply, and DairyNZ as the organisation that is paid a levy to help the farmers manage their farms. Although the term does include the dairy farmers as a collective, this thesis considers the individual farmers actions and pressure of the larger entities.

Riparian corridor – Literally translated the Latin word *ripa* means "river bank" (Parliamentary Commissioner for the Environment, 2012). Riparian margins are defined as the area that connects terrestrial and aquatic zones (Ministry for the Environment, 2001). This thesis refers to *riparian corridors*, which includes the waterway and the riparian margins up until the edge of the pasture.

Planting – the term *planting* is used throughout the research in reference to vegetated riparian corridors that have more specific plants, as opposed to the solely grassed corridors.

Best Management Practice (BMP) – defined by Parliamentary Commissioner for the Environment (2004), best management practice is a standard that is developed by industry as a bench mark for land management. *Good Management Practice* (GMP) is a subset of this. GMPs have been developed as "the reasonable management actions that farmers could be expected to take when farming well" (Williams et al., 2014, p. 3). For consistency BMPs will be addressed throughout this thesis.

Corridor design - refers to the spatial configuration and features of the riparian corridor (e.g. its length, width, and characteristics including choice and positioning of stock exclusion, and types and placement of plants). In other words it is the approach to implementation of riparian corridors. It is normally included in the industry's term 'riparian management', which implicitly includes design and implementation. However, 'riparian management' as used in policy and industry best practice literature frequently pays little attention to everyday management and maintenance practices (see next entry).

Corridor management - refers to how the riparian corridor is managed following installation of the design, including such activities as irrigation, weed control, or thinning or trimming vegetation and maintenance in support of corridor functions.

Riparian buffer - is used to describe the distance between the fence and the waterway.

Action - Corridor design and management actions are referred to throughout the results. The term *action* is in reference to the actual activities taken by the informants in their riparian corridor design and management.

1.3.4 Organisation of Thesis

This thesis is organised in seven chapters. The next chapter (Chapter 2) describes the effects of dairy intensification on surface waterbodies, the functions riparian corridors provide, and the riparian design strategies that have been established. Chapter 3 describes the policy and industry framework within which riparian corridors are designed and managed, with particular focus on Canterbury as a case study. Chapter 4 discusses the current evidence of design and management implementation and the critical issues for implementation established by the literature. Chapter 5 outlines the method used for the interviews and data analysis. Chapter 6 reports on the findings of the research. Finally, Chapter 7 discusses the implications of the findings for science, practice and wider policy. Table 1.1 below summarises the organisation of this thesis and the relationship to the methods used.

Chapter	Steps	Methods & Sources
Chapter 2	Describe the current theory behind riparian corridor functions	Literature Review
Chapter 3	Outline the framework of policies and practices that give context to riparian corridors in Canterbury and the goals and objectives defined in them.	Literature Review
Chapter 4	Evaluate the evidence of implementation, identify known critical issues for implementation, the current knowledge concerning the extent of implementation and identifies the gap that will be address in this research.	Literature review
Chapter 6	Describe the participants' experiences of riparian corridor design and management, the rationale for actions, the priorities and the type of action, how success is evaluated and the factors that influence the success of design and management.	Results from interview analysis
Chapter 7	Discuss how farmers' corridor design and management relate to science literature, Best Management Practice and wider policy, and the implications for policy, practice and management regimes	Integration of literature review and results from farmer interviews

Table 1.1 Summary of thesis

1.4 Summary

Increasing intensification and declining water quality has led to significant pressure from the New Zealand public and prompted a response from both government and industry, in the form of voluntary agri-environmental programmes including the Dairying and Clean Streams Accord and the

latest version titled the Sustainable Dairying: Water Accord. These programmes champion the use of riparian corridors to mitigate the effects of intensive land use such as dairying.

Multiple forms of research has investigated the effects of dairy on water quality, the functions of riparian corridors, the viability of mitigating impacts using riparian corridor practices of stock exclusion and re-vegetation, the extent of implementation, and ways to encourage land owners to implement such practices. However there is less known about the experience of dairy farmers over time in relation to the design and management of riparian corridors. This thesis addresses this gap. Using an interpretive case study of Canterbury dairy farmers, interviews have been conducted to establish their experience and the implications of that experience in improving future policy and programmes focused upon riparian corridors.

The next chapter establishes the effect of dairy farming on water quality and the functions of riparian corridors. It also considers best management practice and the effect of corridor design in terms of stock exclusion and vegetation.

Chapter 2

Riparian Corridors and Dairy Farming

In New Zealand, farmers of intensive dairying landscapes are under political and commercial pressure to design and manage their farms in ways which do not lead to unacceptable impacts upon New Zealand surface water systems. This section reviews the literature on the issues concerning dairy farming and surface water, riparian corridor functions and how they are implemented in dairying landscapes. Section 2.1 establishes the impact of intensive dairy farming on riparian corridors and water quality. Section 2.2 outlines the riparian functions that have been identified to affect the condition of surface waterways. Section 2.3 determines the best management practice with respect to dairy farm riparian corridors. Section 2.4 is a summary of the chapter.

2.1 The Effects of Dairy Farming on Waterways

One of the most significant contributors to the degradation of surface water quality is dairy farm intensification (Bewsell et al., 2007). Modelling has shown that the major cause of water quality decline is the scale of dairy farm expansion, resulting in more hectares holding more cows per hectare (Parliamentary Commissioner for the Environment, 2013). Land use activities such as dairy farming are reported to increase nutrients, pathogens, sediment, temperature and turbidity of surface water and waterways (Environment Canterbury, 2008). In terms of interaction with riparian corridors, these issues can be associated with two characteristics of dairy farming; the entrance of stock into waterways and the loss of vegetation in these landscapes.

Stock entrance into waterways is a major cause of water quality reduction as it increases faecal bacteria and trampling which increases sedimentation and destroys the habitat of the waterway (Bewsell et al., 2007; Wilcock & Wright-Stow, 2012). Davies-Colley et al. (2004) showed the impact of a herd of dairy cows on water quality by monitoring the crossing of a stream ford. Turbid water associated with high concentration suspended solids and nitrogen was produced, along with pathogens contained in animal waste which cause disease in both humans and animals. Direct manure deposits are due to livestock, dairy cows in particular, that defecate while they are in water (Parliamentary Commissioner for the Environment, 2012). Davies-Colley et al. (2004) found that when they compared the cows' defecation as they crossed a stream with their defecation over the rest of the raceway, to and from the dairy shed, they defecated 50 times more in the stream than anywhere else on the raceway. Indicating that cattle access to waterways can cause noticeable contamination, and water quality benefits can come from the exclusion of stock.

The absence of riparian vegetation is common place in agricultural landscapes and it leads to increased water temperatures, turbidity, algal blooms, sedimentation and stream bank erosion (Sinton, 2008). The removal of the original forest cover throughout New Zealand exposed soil and sped up the process of erosion that would naturally have occurred and the consequence is an excess of sediment in waterways (Parliamentary Commissioner for the Environment, 2012). Soil additionally enters waterways when riverbanks are broken down by animals and when soil is exposed by overgrazing. Sediment entrance rates have been measured to increase by two to five times in pastured landscapes compared to the rate of equivalent areas of forest (Blaschke et al., 2008; Elliott et al., 2005).

Sediment smothers the beds of waterways and therefore impacts upon water quality. The blanket of mud and silt created by sediment effects aquatic ecosystems by overwhelming habitats, and it also provides a base for exotic weeds. The build-up of sediment can change water flows, reduce the capacity of waterways and increases the entrance of phosphate as it clings to sediment (Unwin et al., 2010). An additional source of nitrogen in waterways is the use of fertilisers on the adjacent land (Quinn, 2003). Pastoral dairy farming requires the use of nitrogen fertilisers to increase crops and are known to leach into ground water and runoff into the neighbouring waterways (Wilcock et al., 2006).

2.2 The Role and Functions of Riparian Corridors

Riparian corridor functions have been recognized in a range of literature with a prominent focus on issues and functions in the New Zealand landscape. The roles vary and are dependent on the geographical setting, vegetation and position in the network of waterways. Their key functions relate to water quality; they contain contaminants, uptake nutrients, decrease bank erosion and offer shade (Quinn, 2003). Quinn (2003) divides the role of riparian corridors into 12 different functions. These functions can be grouped into three different categories; land management functions, ecosystem support, and recreation and amenity values.

2.2.1 Land Management Functions

Functions that relate to the terrestrial aspects of riparian corridors include the ability to maintain bank stability and therefore the prevention of erosion as well as filtration of runoff. Further roles for land management are in reference to the ability of riparian corridors to manage nutrients coming from adjacent land use by providing nutrient uptake and denitrification (Quinn, 2003).

Erosion control

Riparian margins address a number of factors in erosion control. Five aspects have been identified by Quinn (2003) that effect the stability of a riparian corridor. These are; the height and angle of the bank, the strength of the waterway's flow, the root depth of vegetation and other features such as boulders which provide protection. This is supported by Blaschke et al. (2008) who claim that reforested catchments reduce the amount of sediment in waterways if it is targeted to areas of high sediment input. These include having a root network that strengthens the bank, plants that cover the ground to prevent surface soil erosion and ensuring that there is drainage to reduce the chance of the bank to slump. This conclusion indicates the need for appropriate planning of riparian vegetation in erosion prone locations. However Berges (2009) notes that the amount of riparian vegetation or the presence of a specific type of vegetation does not necessarily ensure bank stability because fluvial processes and upstream and downstream land uses cause continuous changes to stream banks.

Filtering of surface water, nutrients and sediment

For a riparian corridor to provide a role in filtering runoff it needs to slow the flow overland, and increase soil filtration of particles (Marchand, 2006; Quinn, 2003). For the corridor to contribute to this function it requires a landscape where surface water runoff is an issue. The likelihood of runoff occurring and therefore the need for this function is increased with rainfall intensity, slope length and angle, soil type and flattening by stock (Howard-Williams et al., 2010; Marchand, 2006; Quinn, 2003).

Where surface water runoff or groundwater passes through the root zone of riparian plants before reaching the waterway, nutrient uptake takes place and is an important function of riparian plantings (Wilcock et al., 2006). The type of vegetation that provides this function in the riparian corridor is dependent on root depth in relation to bank height and groundwater depths. Larger plants and shrubs have deeper roots, and trees store more nutrients as they have a greater biomass. Having these plants closer to the stream means they are likely to interact with the ground water, although nutrient uptake can be done at greater widths with plants that have an increased root depth (Marchand, 2006; Quinn, 2003).

Further to filtering and nutrient uptake riparian corridors can provide denitrification. This function is the process of removing nitrogen from water (Quinn et al., 2001). Nitrogen in waterways causes changes to trophic state, increases toxic algal blooms and can impact upon the health of babies through blue baby syndrome (Parliamentary Commissioner for the Environment, 2004). Consequently the function of the riparian corridor to reduce the input of nitrogen into waterways is

important. The process involves bacteria that reduce nitrate to nitrate oxide and other gases which are lost to the atmosphere (Quinn, 2003). This function occurs in waterlogged and poorly draining soils with buried organic matter because they provide low oxygen and carbon sources needed for the process to happen (Webb et al., 2010). Therefore this process often occurs in areas where shallow ground water passes through wetlands before emerging in a stream. Riparian plants are important in this function to provide sources for buried organic matter, the carbon source for the process (Wilcock et al., 2006).

2.2.2 Ecosystem Support

Riparian corridors provide functions that support aquatic habitats in several ways. Firstly the shade provided by vegetation helps to improve instream temperatures and control the growth of unwanted in-stream plants. Secondly riparian margins can help to provide for healthy ecological habitats.

Shade provision

The provision of shade is a key riparian corridor function associated with vegetated corridors. Shade offers improvements to waterways by decreasing temperature and controlling in-stream plant growth. This role is important as it delivers a limiting factor to water quality issues such as eutrophication (Rutherford et al., 1997).

Shade provided by vegetation is one of the significant corridor design concepts identified in the literature (Burrell et al., 2014; Collins et al., 2013; Parkyn et al., 2003; Parliamentary Commissioner for the Environment, 2012; Rutherford et al., 1997; Wilcock & Wright-Stow, 2012). Vegetated riparian corridors provide shade to waterways and have a role in reducing stream temperature, and vegetation is the main factor in improving the trophic state (the weight of biomass in a waterbody) as it reduces the effects of nutrients on the waterway (Burrell et al., 2014). Parkyn et al. (2003) found that invertebrate communities improve in health when stream shade is enough to reduce the temperature of the water. In areas where the water has no shade, cool groundwater entering shallow streams heats up quickly. This rate of increasing temperature decreases as streams get deeper or with an increase in streamside vegetation. The role of the riparian vegetation in shading waterways is reduced as the width of the waterway increases (Parkyn et al., 2003). Tussock grasses and flaxes are best in shading narrow channels while mature trees are useful for medium sized waterways (Quinn, 2003). It is also suggested that landscape features such as banks and hills can also provide shade in addition to vegetation (Ministry for the Environment, 2001).

The control of light penetration into riparian corridors also controls the growth of algal blooms such as toxic blue green algae (*cyanobacteria*) and filamentous green algae (Burrell et al., 2014; Collins et al., 2013; Parkyn et al., 2003). However processes that exist instream to remove nutrients are reduced when shade is increased which means more nutrients are carried downstream (Quinn, 2003). Although leaf litter does take up some instream nutrients, it is not enough to compensate for the reduced uptake that takes place when the area is well shaded (Rutherford et al., 1997). Hence there needs to be a balance between shade increase and the uptake of the plants in the riparian margin that are producing the shade. According to Quinn (2003) the downstream receiving water nutrient concentrations need to be analysed to determine if they are more important than instream weed growth and high temperatures in tributaries. If this is the case riparian plantings need to be planned to maintain light conditions so that instream nutrient removal processes are maintained.

Habitat provision

Healthy aquatic ecosystems are often used as indicators of high water quality. Aquatic environments benefit from corridor functions through macroinvertebrate habitat provided by leaf litter and wood inputs. Additionally fish habitat is improved due to the food sources and shelter offered by vegetated riparian corridors. Inputs of leaf litter and wood offer both a habitat and a food resource function. These functions depend on the size of the stream and flood frequency. Smaller streams have flood flows with low power which fail to push large bits of wood downstream which provide habitats (Marchand, 2006; Quinn, 2003). Overall it is suggested that design and management of a riparian corridor, whether it is fencing or planting, has only a small, localised impact on downstream water quality and habitat. However if it is adopted as a preventative measure, in areas where the reach is reasonably unaffected, it is suggested that a decline in instream habitat can be avoided (Greenwood et al., 2012).

Fremier et al. (2015) indicate that riparian vegetation allows for habitat connectivity between aquatic and terrestrial zones. Fish habitat is provided by riparian vegetation as it provides cover and also offers food sources such as terrestrial insects from overhanging vegetation (Renouf & Harding, 2015). The removal of riparian vegetation has reduced the suitability of many tributaries for fish spawning (Quinn, 2003).

2.2.3 Recreation and Amenity Values

Public and private benefits are provided through recreation functions and amenity of riparian corridors. Recreation is influenced by a number of factors identified by Quinn (2003) as aesthetics,

naturalness, access and angling capabilities of the stream. The role of the riparian corridor can be to provide for these aspects (Marchand, 2006; Quinn, 2003).

According to Quinn (2003) riparian vegetation also provides aesthetic values. Publicly, riparian corridors that are well managed are valued for aesthetic reasons, as well as for water quality. Pure clean water and continuing flows of streams as well as vegetated and well managed areas have been identified as a public preference (Kerr & Swaffield, 2012). This is a similar concept to that mentioned by Kenwick et al. (2009) who note that woody vegetation is preferred over no planting and that the provision of habitats for wildlife as well as visual appeal are valued. Aesthetics also offer an indication of care. According to Nassauer (2011) care is a concept that considers what is visible and seen by others. The aesthetics of a landscape affect the perceptions public have about the people who are responsible for providing care for that landscape.

2.3 Design of Riparian Corridors

Riparian corridors have been recognised by industry as an area in intensively farmed landscapes that can be adapted to provide improvement in water quality as well as develop on-farm biodiversity (DairyNZ, 2012). The benefits of a well-managed and restored riparian corridor are documented both internationally and in New Zealand literature (Hansen et al., 2015; Ministry for the Environment, 2001; Parliamentary Commissioner for the Environment, 2012; Reich et al., 2011; Wilcock et al., 2009). This recognition is also made by the agricultural sector, public policy and by companies as a way of addressing environmental issues. However one size does not fit all and approaching design and management in such a way can prove ineffective for improved water quality (Quinn et al., 2001).

In agricultural areas, design of riparian corridors is promoted as a “best management practice” by industry and regional councils and often endorsed as a significant instrument in environmental management (Renouf & Harding, 2015; Wilcock et al., 2009). Two prominent actions for managing riparian corridors are fencing and planting. BMPs for riparian corridors can be divided into three types; fencing-off the corridor to exclude stock, restoring the corridor through planting and a combination of the two (Wilcock et al., 2009). Science literature has assessed the effectiveness of these recommended BMPs to improve upon water quality parameters (Wilcock & Wright-Stow, 2012). This section discusses the current literature that relates to riparian corridor design, the benefits of each practice and the previous studies into effectiveness for achieving water quality improvements.

2.3.1 Stock Exclusion

Fencing for stock exclusion is a prominent form of BMP. Wilcock and Wright-Stow (2012) showed how BMPs such as riparian fencing can improve stream health. Their results indicated that improvement is slow, although the reduction of sediment loss from land due to stock exclusion had positive results. The findings attribute an increase in stream fencing in their five case study sites over 10 years from 50% to 80% as a significant reason for the suspended sediment concentrations in waterways being reduced (Wilcock & Wright-Stow, 2012).

Width of riparian buffers is an aspect of riparian corridor design debated in the literature. Areas of un-grazed grass can prevent the entrance of phosphorus nutrients, therefore a temporary electric fence can have a significant effect according to the Parliamentary Commissioner for the Environment (2012) report. Wilcock et al. (2009) indicate that un-grazed pasture within fenced riparian buffers also filter particulate contaminants from surface runoff. In terms of the distance of the fence from the waterway, one estimation is that a 4 metre vegetated buffer width may achieve 95% reductions in faecal bacteria inputs on flat to undulating slopes (Wilcock et al., 2009). Parkyn et al. (2000) identify that width should depend on the intended function. Some nutrient movement can be affected by a grass buffer of 10 metres which can remove more than 50% of nutrients, and buffers of 20 – 30 metres remove 100% (Parkyn et al., 2000). However Renouf and Harding (2015) suggest that while grassy un-grazed riparian corridors can be sufficient to intercept and retain sediment, suspended solids and faecal contaminates, they do not have the ability to take up other pollutants from agriculture such as nutrients in surface runoff and shallow groundwater flows, which can only be achieved through targeted, specific vegetation.

In addition to improving water quality, other reasons for fencing riparian corridors have been identified. Bewsell et al. (2007) state that farmers invest in stream fencing for reasons such as fencing for boundaries, preventing stock from getting stuck in waterways and to maintain animal well-being. They also found that there was slow adoption of riparian fencing due to a belief that it would be of no benefit to stock management or they were not being pressured externally to fence at the time. This research focused on the presence or absence of corridors rather than the features of corridors, therefore indications of the amount of fencing or buffer widths were not established.

2.3.2 Riparian Vegetation

Planting is recognized as important to restoring stream health. Renouf and Harding (2015) believe that the planning and planting of riparian corridors is of vital importance and has the potential to be

an instrument that is essential in mitigating land use intensification impacts of the past, present and future.

Various aspects of vegetation in riparian corridors have been examined. Parkyn and Davies-Colley (2003) outline that rapid improvement in water quality can be attributed to well established vegetation. The width of vegetated riparian corridors is often considered to be of importance for riparian corridors to provide functions for improving water quality (Hansen et al., 2015; Ministry for the Environment, 2001; Parliamentary Commissioner for the Environment, 2012; Reich et al., 2011; Wilcock et al., 2009). However, as with grass buffer widths, information concerning the issue of riparian vegetation width is inconsistent. This may be due to an understanding that widths of different sizes can address different functions, combined with the aim of maintaining the ability to use surrounding land (Parkyn et al., 2000). A common concept relating to buffer width is to have enough space for vegetation of various heights and ground cover so that multiple aquatic functions can be met. To reduce water temperature, 80% shade can be provided by a single line of trees but for the microclimate conditions of a forest to be replicated a buffer of 40 metres has been identified as necessary (Parkyn et al., 2000). In contrast, Collins et al. (2013) concluded that width did not matter, a limited number of parameters such as turbidity and dissolved oxygen can be improved even with a narrow planted riparian corridor. Consequently Hansen et al. (2015) claim that despite a high volume of riparian research, the evidence is uncertain, and inadequate to demonstrate that certain widths achieve particular ecological functions.

A number of authors claim that the benefits, such as shade and habitat values, to waterways within intensive landscapes occur once *any* amount or type of vegetation has become established (Burrell et al., 2014; Collins et al., 2013; Dodd & Ritchie, 2007; Parkyn et al., 2003). Parkyn and Davies-Colley (2003) note that macroinvertebrate indicators improve and become “clean water” communities once vegetation provides stream shading enough to reduce water temperatures. Renouf and Harding (2015) claim that there are many riparian corridors in the Canterbury region that need further establishment of vegetation to mitigate the adjacent land use intensification, believing that this can be done within the areas that have already been fenced off. The positive functions such as biodiversity, aesthetics, improved shade and habitat that vegetated riparian corridors provide mean that it is a tool that enhances the waterway in more ways than a fenced waterway with no planting established (Renouf & Harding, 2015).

2.3.3 Riparian Design Strategies

The advantages of fencing and then vegetation to mitigate the effects of land use intensification mean that both approaches to corridor design are encouraged. The capability of riparian corridors to provide the functions, established in Section 2.1, depends on land form and stream size (Quinn et al., 2001). Shade for instance is more effective on narrower streams which are more likely to be affected by shade from riparian corridors compared to wider channels (Burrell et al., 2014; Rutherford et al., 1997). The capacity of a riparian corridor to address contaminated transport is dependent on the soil type and the amount of overland flow that the area experiences (Quinn, 2003).

For riparian design and management to be successful and mitigate the impact of dairy farming on water quality, small waterways and tributaries of the main rivers are important. This is because they are more vulnerable to adjacent land uses, and therefore riparian corridor functions are critical and could reduce the cumulative impacts in the larger waterbodies (Greenwood et al., 2012).

Overall the scientific evidence suggests that the type of management that should take place depends on the focus of the project. Hansen et al. (2015) suggest that clear objectives and consideration of the environmental context define the effectiveness of riparian designs. Quinn (2003) proposes that waterways should be classified by width and geomorphology so that the effectiveness of different riparian design and management techniques address these classifications and can be used to meet site or catchment goals.

Fencing is a critical action used to address water quality issues such as erosion and sediment inputs, increased pathogen presence and phosphorus contribution. While the action of planting is to prevent nutrient and sediment entrance as well as increase shade reducing temperature and light penetration and therefore the growth of algal blooms (Parliamentary Commissioner for the Environment, 2012). Miller et al. (2010) indicate that riparian fencing is a step towards introducing riparian planting, and fencing for stock exclusion means that the standing litter and cover from canopy increases and thus increases stream shade.

The monoculture created by pastoral farming means that riparian planting provides an opportunity to introduce plant diversity back into the landscape. As riparian buffers are unique in their position, connecting aquatic and terrestrial zones, the habitats and ecological processes, biodiversity can be established or re-established into these areas through a combined fencing and planting strategy (Arthington et al., 2010; Fremier et al., 2015; Naiman et al., 1993).

2.4 Summary

The management of riparian corridors is often seen as the last line of defence in protecting water quality in streams and rivers, with the key functions ranging from uptake of nutrients, reducing bank erosion, limiting direct deposition of faecal bacteria, the containment of contaminants and improving instream conditions through shade and provision of leaf litter. Few studies have considered or identified any detrimental impacts on water quality of either fencing or riparian planting of riparian corridors.

New Zealand's water quality decline in agricultural areas undergoing intensification has prompted a number of actions. Dairying landscapes in particularly have been targeted and the exclusion of stock from waterways has become imperative due to the effect high stocking rates are having on tributary and waterways in general. In addition non-point source discharges have become a major concern in these pastoral landscapes with dairy farming often identified as the party at fault.

Due to functions relating to reduced nutrients, erosion, contamination and improved instream conditions provided by specifically designed riparian corridors, it has become commonplace in intensive dairying landscapes to implement corridors. Design strategies include different approaches to both fencing and planting and it is recognise that there is a necessity for specific objectives to be identified and targeted designs implemented.

The next chapter uses evidence from both scholarly literature and government reports to examine the current policy framework for riparian corridor design and management.

Chapter 3

Policy Framework for Riparian Corridors

Policy Frameworks to encourage implementation of riparian corridors include both regulatory and voluntary approaches. The national response to water issues including water quality degradation has been predominantly identified as soft, voluntary measures, with policy initiatives from central and local government sitting alongside those from the private sector (Memon et al., 2011).These voluntary approaches established by the dairy sector itself identify corridor design and management as an instrument that should be used alongside other mitigation measures. This section establishes the policy context for statutory regulation and industry initiatives that establish BMPs specifically for riparian corridor design and management. Section 3.1 establish government policy context for water resource management in New Zealand. Section 3.2 identifies the industry-initiated policies and programmes (BMPs) for designing and managing riparian corridors in dairy landscapes, and Section 3.3 is a review of riparian corridor design from industry and regulatory guidelines. Section 3.4 is a summary of the chapter.

3.1 Statutory Regulation

3.1.1 Policy Context

National policy context

New Zealand's overarching environmental management legislation is the Resource Management Act (1991) (RMA). Cited as leading environmental legislation, the RMA identifies sustainable management of natural and physical resources as its main purpose, intending that resource use is regulated according to the "life supporting capacity" of the environment (Snelder & Hughey, 2005). The Act aims to establish high-level goals and mechanisms for management, yet remain nonprescriptive in terms of criteria for management and objectives in regards to water quality standards, for example. The RMA replaced and consolidated a large number of separate statutes and integrated them into a framework for planning and resource management (Fisher & Russell, 2011). The objective of balancing socioeconomic needs with environmental needs is guided by the principle of sustainable management. However the way in which this term is interpreted has been a point of contention among stakeholders, planners and the Environment Court (Memon et al., 2011). The RMA is based upon an ideal of subsidiarity, meaning that decisions should be made as close to the community level where the benefits or interests arise (Memon et al., 2011).

As part of the RMA reforms the governance of freshwater has undergone extensive restructuring (Memon & Kirk, 2012) with a wide range of changes to the planning framework. Water resource management decision making is delegated to 16 regional councils. These councils are elected with the territorial boundaries often defined by large river catchments or groups of adjoining catchments (Memon et al., 2011). These regional authorities produce a regional policy statement which outlines the issues and needs of the region, and regional plans that contain policies, objectives and rules for management of resources including water. These regional policy statements and plans are the key regulatory mechanisms employed by regional councils (Snelder et al., 2014).

There has been criticism from different sides about the ability of regional governments to implement and produce acceptable water planning policy and regulations (Memon & Kirk, 2012). While some resource users fail to see the need for the regulations imposed on them, others are concerned the environment is not properly protected. Regional plans have also been criticised for their vague objectives and lack of management accountability (Snelder et al., 2014) and the approach to resource management is often on a case by case basis, which has been acknowledged as inadequate in addressing the cumulative effects or full implications of a resource use (Parliamentary Commissioner for the Environment, 2015b). Due to the nonprescriptive nature of the RMA itself, the most important key to success is regional-scale environmental planning and policy (Snelder & Hughey, 2005). However policies are often expressed as qualitative objectives, and plans fail to provide the framework for addressing existing and cumulative effects (Snelder & Hughey, 2005). The inability to successfully control diffuse non-point source pollution has been identified as the major concern for New Zealand's water quality management, and there is debate about whether this is due to weaknesses in the RMA itself or in its implementation (Memon et al., 2011).

As shown in the previous chapter, in intensive agricultural landscapes there is a need to protect water quality and regulate diffuse non-point source pollution. Creating rules that achieve this has been recognised as difficult and the preferred approach is to advocate and educate, as it is assumed to be more effective (Memon, 1997). The mandate from central government has over the years been for regional councils to exercise water management with 'light handed regulation' and financial incentives. For example Canterbury's Natural Resources Regional Plan (2011) policies for stock exclusion were to be "encouraged and promoted" rather than regulated (Environment Canterbury, 2011a). The focus has been to rely on self-regulation and voluntary approaches.

Particular to riparian corridors the RMA identifies in Section 6 "the preservation of the natural character of wetlands, and lakes and rivers and their margins" as a matter of national importance. The use of regional and district level planning processes is identified as the way to achieve these

objectives providing protection for riparian corridors and if need be change land-use practices in these areas (Memon, 1997). However policy focus has remained on voluntary and community action. Memon (1997) claims corridor design and management would only be achieved with landowners actively supporting it and the formation of land care groups seen as a means to success. This reluctance to regulate riparian corridor practices may have been due to caution around being seen as too interfering by the farming community, however the ability of this self-regulation and voluntary approach has been debated (Memon et al., 2011; Parliamentary Commissioner for the Environment, 2015a).

The increasing necessity for public policy to address New Zealands' water issues under the RMA led to a work programme known as 'A New Start for Fresh Water' (Miller, 2011). This national programme had three parts; policy development by government agencies; engagement between iwi leaders and Ministers; and the establishment of an advisory group to direct Ministers on how water should be managed- the Land and Water Forum (LAWF) (Fisher & Russell, 2011; Miller, 2011). This forum brought together a range of interested parties to collaborate and produce a report of recommendations which informed the production of the National Policy Statement for Freshwater Management (NPSFM) (Fisher & Russell, 2011). The NPSFM (2011), and its replacement in 2014, focus on setting enforceable water quantity and quality targets, with the intention to address agricultural diffuse pollution (Duncan, 2014). The NPS identifies riparian fencing and planting as a mitigation tool to be used in unison with other water management techniques to improve water quality and reduce contamination of waterways (Ministry for the Environment, 2014b). It also suggests that funding for riparian fencing be set out by regional councils in annual plans.

Other central government moves to manage water issues include tax deductions introduced to allow farmers to deduct for riparian planting, where the intention of the planting is for preventing erosion, runoff and providing shelter (Ministry for the Environment, 2007). Funding was also provided by central government in the form of the Environment Enhancement Fund (EEF), which aimed to support enhancement projects such as riparian planting in certain areas of New Zealand. Environment Canterbury utilised the fund for protection and enhancement of over 64 kilometres of riparian corridors for example (Tait & Cullen, 2006). Central government has introduced the "fresh start for freshwater" fund providing financial means for riparian corridor restoration (Miller, 2011).

Regional policy context

At regional level a Regional Policy Statement (RPS) outlines the intended outcomes and issues that should be addressed in the region's Regional Plans. RPS sets out the issues, objectives, the policies

for each objective and methods for regional and local councils. Regional Plans prepared by regional councils to address the objectives of the RPS also have objectives, policies and rules.

In Canterbury a shift for water management came about with the investigation into the Canterbury Regional Council's performance in production of a regional plan and processing of water consents in 2009. This resulted in government appointed commissioners taking over for all of Canterbury's regional councillors. Additionally legislation to side-step RMA decision-making provisions was put in place. This dramatic legislative intervention has been criticised as being a response disproportionate to the issue. Core to the problem is the removal of democratic decision making, central to local government (Fisher & Russell, 2011). The Canterbury Water Management Strategy (CWMS) became the driving force of what was advocated as a new form of collaborative governance for the region. The CWMS expects that water quality is improved and nutrient loss is limited while increasing irrigation in the region is the outcome of farmers moving to BMPs and if required beyond them (Duncan, 2014).

3.1.2 Canterbury Regional Plans

The overall goal generated at the national level and present in both Canterbury's RPS and Regional Plans is the intent to safeguard freshwater ecosystems and the health of people. The specific measurable objective that comes from the NPSFM identifies that water quality needs to be at or above the level of secondary contact, meaning that a person should be able to at least wade or boat in a waterbody (Ministry for the Environment, 2014a). This goal falls short of public opinion as Hughey et al. (2010) identify, New Zealanders value unpolluted waters that are swimmable.

In Canterbury the Regional Council's Natural Resources Regional Plan (2011) (NRRP) identifies the issues to do with water quality, the objectives to address this, and policies, methods and rules that indicate how the objective will be achieved. In terms of riparian corridors the NRRP indicates that riparian planting should be promoted for water quality reasons and restoration of indigenous biodiversity that may be lost from riparian corridors. The only exception is that this rule does not include manmade waterways such as farm drains, stockwater races and irrigation canals (Environment Canterbury, 2011c). In terms of clear measurable objectives the NRRP (2011) identifies set water quality standards and establishes criteria for water quality of different waterbody types.

The more recent Canterbury Land and Water Regional Plan (2015) (LWRP) is the latest planning document to be produced in Canterbury. It was effective from January of 2014 and was made partially operative in September 2015. The plan describes riparian protection such as fencing for

stock exclusion and vegetation undertaken to improve water quality in rivers, streams and drains (Environment Canterbury, 2015b).

LWRP (2015) goals seek to improve water quality parameters such as sediment, phosphorus, faecal coliforms, removal of some groundwater nutrients, and also promote the aim to achieve greater biodiversity through vegetated riparian corridors with set water quality outcomes identified (Environment Canterbury, 2015b). The LWRP (2015) aims to identify water quality limits and policies that ensure community drinking water is drinkable and quality of water at valued bathing areas is at a level for primary contact.

Table 3.1 compares the policy goals and methods which are in the two plans; the Natural Resources Regional Plan (2011) and the Land and Water Regional Plan (2015). These are shown to present the current framework that shapes riparian corridor design and management of dairy farmers in Canterbury.

	NRRP (2011) (Environment Canterbury, 2011a)	LWRP (2015) (Environment Canterbury, 2015b)
Goals	General overall: Safeguard fresh water ecosystems and health of people.	
	• Nutrients • Pathogens • Fertiliser • Sediment • Erosion • Biodiversity • Flood capacity • Habitat	• Soil stability • Stock induced effects are avoided • Nutrient loss • Biodiversity • Amenity values • Farming activities operate at good practice, • Swimming, • salmon spawning
Objectives	• Setting water quality standards • Identifying waterbodies with a water quality standard to sustain and ones to be improved.	• Set water quality limits. • Policies ensure community drinking water drinkable, • Level of primary contact recreation for parts of rivers valued bathing
Method	• Promote vegetation for water quality • Provide general guidance • Promote stock exclusion • Information and promotion • Identify priority surface waterbodies • Create riparian management strategy • Regional rules • Advocacy • Riparian management strategy • Incorporate BMP into Environment Canterbury owned land • Environment Enhancement Fund	• Sedimentation and erosion is avoided or mitigated • Stock exclusion from rivers, swimming, salmon spawning sites • Monitor and raise awareness of nutrient loss • Promote sustainable farming practices • Enhance indigenous biodiversity and amenity values • Water quality, indigenous biodiversity and ecosystem health are enhanced through establishing or restoring riparian planting.

Table 3.1 Summary of Canterbury's recent regional policies that are relevant to water quality and shaping farmers approach to corridor design and management (Environment Canterbury, 2011a, 2015b)

This framework of plan rules shapes riparian corridor design and management carried out by dairy farmers in Canterbury. From these, plans, methods and rules are designed to apply the policies. The policy, method and rule sections of the regional plans give a focused strategy to managing water resources and show what is required of land managers and for the purpose of this research, dairy farmers, in the design and management of riparian corridors.

As shown in the above Table (3.1) the 2011 NRRP details policies for non-point source discharge through the management of riparian zones (Policy WQL5 and WQL6) by excluding stock and promoting the retention, maintenance or planting of riparian vegetation. These policies use methods such as advocacy, information and promotion and the EEF to encourage implementation (Environment Canterbury, 2011a).

Stock exclusion is the most obvious method to achieve goals for water quality. Rules allow access of stock to waterways only if significant adverse effects are avoided. These adverse effects include pugging, reduction of water clarity, increase in bacteria and obvious evidence of faecal matter (Environment Canterbury, 2011a). Stock exclusion buffer strips are used to filter runoff and take up nutrients, manage erosion and combined with an on-farm management approach (Environment Canterbury, 2011a).

In the 2015 LWRP policies are concerned with soil stability, stock exclusion, nutrient management and the riparian margins themselves. In addition freshwater outcomes for Canterbury rivers are defined using ecological, macrophyte, peryphyton, siltation and microbiological indicators for each type of waterway. Other policies and rules focus on awareness and monitoring of nutrients, fertiliser use, earthworks and vegetation clearance in the riparian corridor. Cattle are suggested in this Plan to be prohibited from entering a permanently flowing waterway at whitebait or salmon spawning sites, upstream of community drink water and when near a river-bathing site. Additionally riparian restoration and enhancement is encouraged to develop riparian planting in drain management to address water quality, indigenous biodiversity and ecosystem health issues (Environment Canterbury, 2015b).

The LWRP promotes strategies to increase biodiversity by prioritising areas with biodiversity already in place and allowing the growth of waterweeds to take up nutrients in waterways (Environment Canterbury, 2015a). Also, Farm Environment Plans (FEPs) are identified in the LWRP as the primary way to determining good environmental practice on farms. “Riparian management” is a section to be covered within FEPs, identifying fencing for stock exclusion as well as riparian planting (Environment Canterbury, 2015b).

3.2 Industry Initiatives

Industry initiatives regarding corridor design and management are an attempt to create a solution that reconciles a number of competing and dynamic values and demands. These include expectations of a predominantly urban public and lobby groups for both conservation and for development, a resistance to regulation by land interests such as farmers, as well as trying to protect the clean green image that is vital to overseas trade (Memon et al., 2011). In this section the most recent history of industry initiatives relevant to dairy farmers is discussed to establish the context in which the informants of this study have designed and managed their riparian corridors.

The most prominent voluntary approach to encouraging implementation of riparian design and management has been the Dairy and Clean Streams Accord (2003). The accord was established between the Ministry of Agriculture and Fonterra in response to the allegations of the "dirty dairying" campaign that the dairy industry faced (Hughey et al., 2010; Memon et al., 2011), giving the impression that the goal of the Accord was to improve the negative public perception they were receiving. This voluntary approach was supported by the Parliamentary Commissioner for the Environment (2004) (PCE) who discusses the concept as an attractive approach with a call for education over regulation. However more recently the PCE has advocated for regional councils to implement more stringent interim measures in "catchments that are under severe pressure from land use change" (Parliamentary Commissioner for the Environment, 2015a, p. 14).

The voluntary approach to regulation has been criticised for its tolerance of poor practices due to the heavy reliance New Zealand has on the dairy sector for export earnings (Fisher & Russell, 2011). Initially farmers and other parties were hostile to the Accord, in part due to limited consultation by Fonterra, though this position seems to have relaxed. However it has been identified that voluntary uptake of actions such as stock exclusion will be partial until it financially benefits the farmer rather than the larger community (Memon et al., 2011).

The Accord sets targets for the implementation of riparian fencing and stock exclusion. For example a performance target was for the exclusion of dairy cattle from 50% of streams, rivers and lakes by 2007 and 90% by 2012 (Ministry of Agriculture & Fonterra Co-operative Group, 2003).

As part of the initiative to encourage compliance Fonterra let it be inferred that stock exclusion was to be a condition of supply (Miller, 2011) meaning that suppliers of milk to Fonterra must have all stock excluded from there waterways by 2013 . This approach creates a contradiction within the industry. The implementation of stock exclusion has been expressed as a voluntary BMP which is down to farmer action, while the suggestion that it is to become a condition of supply has consequences for dairy farmer's production hence effectively forcing implementation. This two-sided

approach shows how the industry walks a line between being an advocate for farmers, a product of market demand, a need to project a positive public image, and a desire to minimise regulation.

More recently the Dairying and Clean Streams Accord has been superseded by the Sustainable Dairying: Water Accord (2013) which was developed by the Dairy Environment Leadership Group (DELG). This group includes representatives of farmers, dairy companies, central government, regional councils and the Federation of Maori Authorities. This Accord sets targets for stock exclusion from waterways and drains to be implemented by 2017, as well as the implementation of riparian planting plans with full implementation by 2030 (DELG, 2013).

The general goals that are outlined in industry initiatives such as the Sustainable Dairying: Water Accord (2013) is identified in the vision they describe at the beginning of the document. The outcomes underpin the Accord aspiration to "recognise, protect and where opportunities exist, enhance the many benefits and experiences New Zealanders enjoy in freshwater" (DELG, 2013, p. 3). This goal leads to the idea of improving waterways for recreation, cultural and human health purposes through the design of riparian corridors and other approaches.

The specific targets that relate to riparian corridors from the 2013 Accord direct the dairy companies desire to encourage their farmer suppliers to have excluded stock from waterways and drains by 2017, as well as introducing ways to progressively plant waterways where plants will improve water quality. All dairy farms are expected to have a "riparian management plan" by May 2020 and full implementation of those plans by May 2030 (DELG, 2013).

Dairy companies such as Fonterra have been required by this Accord to produce programmes such as the Fonterra Water Management Programme. This programme imposes the minimum requirements of the Accord to have fenced waterways on all suppling dairy farms. Aiming to reduce the loss of phosphorus, sediment and contamination from faecal bacteria on Fonterra's supply farms (Fonterra Co-operative Group, 2013). Dairy companies also now provide support for this through the use of sustainable dairying advisors. DairyNZ also commit to promoting implementation, and support and encourage farmers to meet the targets (DELG, 2013).

Industry practices rely on stock exclusion as the most prominent strategy to address water quality issues and the strategy for vegetation is only used for improving water quality (DELG, 2013) rather than biodiversity, increase shade or improving habitats.

Industry predominantly advises fencing and temporary fencing of swales and gullies. Drain battering at 45 degrees or less to prevent bank erosion is a more recent approach. Planting is also a tool used for the benefit of water quality (DairyNZ, 2015a). Industry guidelines also suggest using planning

tools such as riparian management plans and Farm Environmental Plans [FEPs]. A riparian management plan in some instances is incorporated into FEPs. The aim of a riparian management plan is to help record the management of riparian corridors over time in the hope that further development of vegetation can be implemented to improve water quality and biodiversity (DELG, 2013).

3.3 Review of Riparian Corridor Design Guides

As established in Chapter 2 the use of BMPs should be based on objectives and type of waterway and landforms involved. To address this, government and industry have identified conditions for implementing riparian corridor design. This section identifies and reviews these specifications. The industry and government conditions for riparian design and management in most cases are a set of options. Each of these options reflects a situation or the amount of effort that is required for implementation and management.

3.3.1 Corridor layout

Fencing is one of the main forms of exclusion implemented in corridor design, where to put the fence and the width of the buffer become the main narratives of these policies' specifications. Goals for nutrient uptake, prevention of erosion and stock exclusion are also based on factors specific to the situation such as flood zone, future vegetation implementation, soil type, drain cleaning and the landforms around the waterway. For example, steep land requires a larger buffer zone, compared to flat land and should be adjusted with the change of the land, "fence set back needs to allow for a grass margin and changes in stream shape and size" (DairyNZ, 2015c, p. 5).

Guides based on waterway type produced by Environment Canterbury make fencing a consideration of riparian practices based on lowland, inland basin and hill country waterways (Environment Canterbury, 2005). In terms of the industry guidelines generally the considerations for buffer width is established around level of mitigation required and topography, slope of the land in relation to the waterway, hydrology, bank stability, land use and the significance of the waterway (MGM Governance Group, 2015).

3.3.2 Access for waterway maintenance

Flood management drains are treated as separate to waterways, and strategies for corridor design and management are different with the conditions that apply to them set out differently in each region (DairyNZ, 2015b). Access for drain maintenance is a prime consideration dictating the placement and type of plants as well as the width of the margins to make drain cleaning possible. The need for drain cleaning is due to the requirements on landowners to maintain the drainage of farm

drains to prevent flooding. Stockwater races are another type of waterway, which historically were used to provide dry stock such as sheep with water, creating a network that criss-crosses much of the Canterbury plains (Sinton, 2008). Allowing for digger access and designing planting to be on one side or low plants for digger access is also part of the specifications for riparian corridors that are planted by drains or stockwater races.

3.4 Farmer Response to Policy Frameworks for Riparian Corridors

Defining the intentions of government and industry helps to recognise the framework for which the use of riparian corridor functions is built and what guides farmers' in implementation. However, it is important to note that goals set by industry are filtered by farmers own perceptions, values and circumstances. Fairweather and Keating (1994) identified the goals and management styles of New Zealand farmers. Central to the knowledge gathered in their study is, understanding how the goals the farmers hold themselves shapes their response to external policies and targets. The research identified that the farmers had predominantly two goals;, economic and lifestyle, which coexist and interact to varying degrees.

In a much more recent report Daigneault and McDonald (2012) discuss the cost and benefit of polices designed with the goal of nutrient management including the management of riparian corridors. They state that the personal goals of farmers contribute to the extent at which a policy is implemented. This is also emphasised by Pannell et al. (2006) who clearly states that the adoption of a BMP such as corridor design and management occurs when the farmer identifies that the practice will improve the achievement of their own individual goals, arguing that it is the subjective perceptions of the farmer that determine whether a goal will be achieved through that approach. This is dependent on the individuals' values, learning process, the social environment and the components of the management practice (Daigneault & McDonald, 2012). The literature shows that effective adoption of environmental practices, such as riparian corridor design and management requires the goals of farmers and the policy to align. Regulation (as opposed to voluntary adoption) can be seen as necessary when there is poor or no alignment of goals. The goals of those farmers who implement corridor design and management need to be therefore identified.

However few studies have addressed this issue in regards to the design and management of riparian corridors as an industry BMP. One study worth noting in this context is Duncan (2014) who identified farmers perspectives on water quality, this study also established a number of key points relevant to farmers response to policy and BMPs. Firstly it identified that BMPs have become part of their everyday farming practices and systems, farmers found that they had no choice but to implement BMPs for milk to be collected and there was a concern that a minority of farmers were creating the problems. Secondly farmers identified that through the use of BMPs they were supposedly making

"head room" for further development of the land and raised questions about who should benefit from the availability made for new development (Duncan, 2014). Finally a disconnection between farmers understanding of the problem and the policy framework understanding of the problem is likely to cause problems for policies and initiatives success. Farmers' perspectives therefore need to be understood and considered (Duncan, 2014) in order to improve policy formation and implementation.

3.5 Summary

New Zealand approaches to encourage the management of riparian corridors include voluntary initiatives, education, financial incentives and regulatory provisions. The RMA is the primary legislation used to manage water resources in New Zealand, with the purpose of "sustainable management" of natural and physical resources. The main responsibility for water management is left with 16 regional councils who are expected to produce regional policy statements and plans that provide policies, objectives and rules.

Approaches to resource management by regional councils have been criticised for a number of reasons including the use of a "light handed" approach with preference for education and encouragement over regulation, a case-by-case approach to consents regulation and an inability to address cumulative impacts on the environment.

Partly as a result, government has become more active, and has proposed an NPS for freshwater. Recently a cross sector forum, the LAWF, provided recommendations to national government on the NPSFM which aims to address freshwater issues, with the main goal to safeguard freshwater ecosystems and health of people.

The planning mechanisms used in the case study area, Canterbury, are the regional policy statement, the NRRP (2011) and most recently the LWRP (2015). There are multiple goals, methods and tools outlined in these documents used to manage water resources. Specific planning objectives, policies and methods have been established within these documents that relate to riparian corridors and the implementation of tools to achieve goals such as water quality, erosion and biodiversity.

Industry initiatives have been used to attempt to reconcile a variety of competing values and demands and expectations of multiple parties have shaped the way in which the industry has approached water management. Allegations of "dirty dairying" and the need to protect the clean green marketing image of New Zealand which is important to overseas trade, led to the Dairy and Clean Streams Accord (2003) and the newly established Sustainable Dairying: Water Accord (2013). Both of these voluntary approaches set targets for the industry with goals for water quality improvements. In addition to education, Fonterra has also suggested compliance for stock exclusion

would be made a condition of supply for farmers (Ministry for Primary Industries, 2013) . While Miller (2011) claims that this tactic has not yet been acted upon, it illustrates a tension in the approach caused by the need to ensure non-compliers improve their management. “Good Management Practices” have also been established as part of an initiative for improved water quality across the agricultural sector.

The framework for riparian corridor policies has been outlined however research also indicates that the success of policies can be determined by the alignment of farmer perspectives and goals with policy goals. The understanding of a problem identified in policy should attempt to incorporate the understanding of the same problem from a farmer’s worldview for BMPs and beyond to be achieved.

Having described the well documented initiatives there remains a significant gap in the knowledge of what is actually happening after implementation and specifically in relation to the question of what is happening in areas where stock have been excluded through riparian fencing, how these corridors should be managed long-term and evidence of this management. This research addresses this need by investigating the experience of dairy farmers who have excluded stock. The next chapter outlines the current evidence of the implementation of riparian design and management techniques and the critical barriers of implementation, as a context for the investigation.

Chapter 4

Farmer Implementation of Stock Exclusion, Planting and their Management

This chapter reviews the evidence of farmer implementation of riparian corridor fencing and planting both nationally and within Canterbury using a combination of government and industry publications and science literature. Section 4.1 looks at what current evidence exists of farmers' implementation of riparian design practices. Section 4.2 describes the critical issues affecting implementation that have been established in previous research, and section 4.3 assesses the extent of corridor management requirements and understanding. Section 4.4 is a summary of the chapter.

4.1 Evidence of Farmer Implementation of Corridor Design and Management

The largest national survey of riparian corridors was carried out by the Ministry of Agriculture and Forestry [MAF] in 2011 (Sanson & Baxter, 2011). This survey focused on the exclusion of stock. Further surveys on implementation of other riparian design methods have not been done on such a scale. Regionally there is some information on riparian implementation but the case study area, Canterbury, has limited comprehensive data on the extent of stock exclusion. In regards to vegetation of riparian corridors there is limited conclusive information and it varies from region to region.

Since the launch of the first Accord in 2003 farmers have been encouraged to implement riparian design actions. These regimes have initially, and especially in the dairy sector, had a focus on stock exclusion fencing. The Dairy and Clean Streams Accord has been continually monitored to gauge the achievement of the targets it set out. The early "snapshots" show rapid improvement while the later snapshots have shown that improvement is slow and dependent on the practicalities to do the job (Ministry for the Environment, 2006, 2007, 2008; Ministry of Agriculture and Forestry, 2009). Today the most recent and final snapshot provided by Fonterra when the Dairy and Clean Streams Accord had come to an end claims that it was a key environmental initiative that improved and supported the dairy industry's social, environmental and economic performance alongside other projects and strategies (Ministry for Primary Industries, 2013). Snapshots collected through personal surveys completed by farmers have been criticised by Fish and Game NZ (an environmental organisation) for being inconsistent (Deans & Hackwell, 2008). The latest snapshot admits that the accord target to exclude 90% of stock had not been met, with 87% of Fonterra farms complying based on the non-

audited verbal assessment (Ministry for Primary Industries, 2013). This assessment involved an assessor meeting with dairy farmers and questioning to gauge the environmental performance.

A physical mapping of fencing for stock exclusion was undertaken in 2011 by MAF (Sanson & Baxter, 2011) based upon data from a quantitative stock exclusion survey undertaken of Fonterra suppliers. The stock exclusion survey measured five hundred and eighty seven farms owned or utilised by Fonterra dairy suppliers randomly selected, with thirteen of New Zealand's regions surveyed. This survey suggested that 78 % of dairy farms nationally had prevented stock access to what was defined as 'Accord' waterways at the time (i.e. those deeper than 30 centimetre and wider than a metre), but only 42 % of farms had complete stock exclusion (Sanson & Baxter, 2011). This survey clearly showed lower levels of full exclusion than the "snapshot" surveys (Ministry for Primary Industries, 2013). Sanson and Baxter (2011) suggest the 2011 survey shows the range of challenges that farmers can face in implementing stock exclusion, and stresses the need for the dairy sector to work in partnership to address them.

In Canterbury specifically, the 2011 survey shows 78% of accord waterways at the time of the survey with complete stock exclusion (Sanson & Baxter, 2011). Canterbury's riparian vegetation has been surveyed in a number of studies using a range of criteria, meaning finding data based only on dairy farms is difficult. However Renouf and Harding (2015) surveyed 88 riparian margins in agricultural Canterbury finding that 48% were 2-5 metres wide and 6% were ≥ 25 m. They noted that the aquatic ecosystems of the sites with the largest riparian widths were the most taxa rich. This study observes that the riparian corridors of Canterbury agricultural streams have a width and complexity that is less than ideal to cope with the intensity of the agriculture (Renouf & Harding, 2015). The results indicate that when the land use activity and intensity has changed the landowners have not changed the type of vegetation within riparian corridors in response. A survey determining the extent, width and type of vegetation in Canterbury corridors has not occurred.

4.2 Factors Determining Farmer Adoption of Riparian Corridor BMPs

This section identifies the critical issues in implementation of riparian corridors that have been defined in previous research, based on the Mitchell's (1997) framework for policy implementation, which provides broad categories that shaped the questions to the informants and organise the evidence. The categories are; goals and objectives; leadership, community and commitment; means; access to information; and farmer values.

Goals and objectives

The success of policy implementation is more easily determined when goals are clearly established (Mitchell, 1997). In the context of riparian corridors the objectives that are identified in the Accord

are clear with the targets and dates for completion set out. However they are at a general level and need translation to particular localities, where implementation needs specific geographical design (Liu & Gu, 2009). FEPs are a tool for tackling local environmental issues, customising initiatives on farms (Monaghan, Wilcock, et al., 2009) and encourages clear objectives to be established that allow for the success of farming BMPs to be assessed (Environment Canterbury, 2015b). Riparian management plans within FEPs recognise that one size does not fit all (Monaghan, Wilcock, et al., 2009) and therefore are an approach that identifies other ways to improve water quality and the way it is done can be tailored to the circumstances in which they are to be carried out.

Leadership, community and commitment

One of the factors identified to affect commitment is the importance of community involvement in encouraging adoption. Community participation in the establishment of corridor design is widely advocated (Collier et al., 1995; Fielding et al., 2005; Kenwick et al., 2009; Ministry for the Environment, 2001; Monaghan, Carey, et al., 2009; Siebert et al., 2006). Collier et al. (1995) suggests that community involvement is vital for the benefits of implementation to be seen and Fielding et al. (2005) identify that a supportive normative environment with influential members of the community are needed to endorse the practice and increase compliance. This idea is reiterated by Kenwick et al. (2009) who claim that community involvement in the implementation of riparian corridor BMPs means that provision of practices that best fit the community are established. Both Monaghan, Carey, et al. (2009) and Siebert et al. (2006) claim that community and social interaction is a key factor contributing to the willingness of farmers to implement and adopt the corridor BMPs they choose to use.

Mitchell (1997) also identified commitment to executing a policy as a key aspect in implementation. In the riparian corridor context, pressure from the dairy industry and regulatory bodies is commonly referred to as a motive for implementation and farmer commitment. The opinions of industry are promoted in publications, field days and through competitions (Jay, 2007), and Siebert et al. (2006) indicate that industry influence is an aspect of socio-cultural context that also influences farmers' readiness to accept BMPs. Industry is significant in the everyday culture of farmers, and is an important influence on their actions (Monaghan, Carey, et al. 2009). Cullen et al. (2006) suggest the role of big business in assisting and validating sustainable management of the environment should not be ignored.

Means

The availability of practical and suitable means is one of the most significant aspects affecting implementation. Financial factors and economic pressure is often identified as a barrier, as they are variables that moderate action and need to be understood (Corbett, 2002). Parminter (2008)

identifies additional costs and a perception of decreased farm production as the main barrier to implementing management of riparian corridors. Monaghan, Carey, et al. (2009) therefore claim that financial cost information is important to implementation and needs to be provided in combination with information on environmental values and conditions.

In regards to funding, Rhodes et al. (2002) examined the financial factors involved in the implementation of corridor design. They suggest that although economic issues are one of the most influential factors for farmers, funding for projects is most influential on farmers who are already involved in implementation rather than those who have not begun. Therefore funding support is important for increasing the extent of implementation rather than encouraging its adoption.

Bewsell et al. (2007) suggest that slow adoption can be due to lack of on-farm benefits, and this leads to a call for riparian corridor design actions to be framed as an investment rather than a cost. Industry information from parties such as DairyNZ (2012) identify the on-farm benefits that can be achieved from implementing riparian corridor practices as well as the benefits to waterways and the broader environment. The various designs for riparian corridors such as planting and fencing produce a corridor that can provide different functions in support of farm management. Fencing of riparian corridors adds to stock security and health, can increase control and grazing management of stock, and reduce the need for drain cleaning. Planted riparian corridors also reduces the need to clean waterways and provide stock with shade and shelter (DairyNZ, 2012).

It has also been observed that the amount of time it takes for establishment, maintenance and the loss of productive land due to the allowance of buffer widths are significant barriers to the adoption of policy objectives (Rhodes et al., 2002). This is a concept also identified by Parminter et al. (1998) who show that new technologies were only selected if they were considered to be practical and did not increase “management complexity”, implying that “means” does not always refer only to financial means, but also includes labour and/or management skill or capacity.

Access to information

Access to information is often seen to be a major factor in implementation of policy objectives (Mitchell, 1997). Information and education are noted enablers of riparian design and have been identified as a key component to sound decision making (Allen et al., 2002) . The Ministry for the Environment (2001) suggests that when knowledge of how to manage riparian corridors exists the progress of implementation is well established. Rhodes et al. (2002) focus their study on the connection of information and implementation of corridor design techniques. The findings show that there is a positive relationship between information that is received by farmers and the adoption of practices. They also claim information and education are the most influential approaches to encouraging initial adoption; however it is less helpful for furthering the extent of implementation.

A number of guiding documents have been published to provide landowners, farmers and other interested parties with information on how to implement riparian corridors. Early sources such as Collier et al. (1995) and the Ministry for the Environment (2001) introduced the technical aspects and justifications of corridor design implementation. More recent guides (DairyNZ, 2014; Environment Canterbury, 2011b) have become more user friendly and orientated towards a particular audience such as farming groups and individuals. Industry specific guides have been introduced as one of the targeted steps set out by the Accord (DELG, 2013), an example of one of these guides is: "*Getting riparian planting right in Canterbury: your step by step guide for successful riparian planting*" which was released as a tool for implementation, providing information on the types of plants the ecosystem services they provide and maintenance requirements of each action (DairyNZ, 2014).

Often the focus of these documents has been to encourage application and they have limited consideration of the maintenance aspects of implementation and the on-going management involved. Robertson (2008) studied whether riparian corridor guides are meeting the needs of the public and discovered that the issue of maintenance was a less important aspect to the landowners using the guides. The findings suggest that the type of plants to use and how to use them was the most desired information.

Farmer values

Farmer values and beliefs are recognised as one of the enablers of BMPs. Collier et al. (1995) argue that any practice that affects procedures already in place is challenging to acknowledge in terms of its benefits. However Jay (2007) argues that it is possible to align intrinsic values of farmers and environmentally positive farm management on the condition that they are rewarded and acknowledged. Additionally Greiner and Gregg (2011) suggest that it is the non-financial motivations that govern farmers' decision making when it comes to conservation practices such as stock exclusion and planting. Ryan et al. (2003) explain that the intrinsic motivations of farmers often are not acknowledged in policy. Intrinsically motivated farmers manage in sustainable and environmentally sound ways due to the attachment to their land, not for economic benefits.

Stock control and animal wellbeing are two examples of farm management advantages that have been introduced in the literature as enablers to manage the riparian corridors in farming landscapes (Bewsell et al., 2007). Parminter et al. (1998) establishes two reasons for farmers to manage riparian corridors. Both relate to the management of farms and the attitudes farmers take towards the organisation of their farms (Siebert et al., 2006). Parminter et al. (1998) first introduce the concept of "pressure farming" which is implementation as a result of issues such as erosion, sediment, boggy areas, and lack of stock safety. The other concept is "conservation farming" which considers how to increase farming income and biodiversity. The preferred corridor design choice for riparian corridors

is based on what would reduce the issues caused by pressure farming, and obtain the benefits of conservation farming.

Siebert et al. (2006) relate the willingness of adoption of practice to farmer values, and Greiner and Gregg (2011) advise that governments use the ambitions and values of farmers when designing conservation programmes, in particular using farmers' stewardship ethic as an instrument for motivation. They suggest that a lack of recognition of non-financial motivations when shaping policy could underestimate the values that make farmers act outside the boundaries of economic rationality. Collier et al. (1995) however suggests that if farmers cannot see on-farm benefits from the practice they are expected to implement then it will be difficult to encourage.

Other literature suggests that it is the relationship between the values that are expressed by landowners and the action that they take that is important (Dutcher et al., 2004). Greiner et al. (2009) concluded that a comprehensive understanding of motivations and risk attitudes of farmers is essential for the enhancement of environmental performance to occur in a farming context. They reveal strong links between motivations, risk attitudes, and the adoption of BMPs such as the design and management of riparian corridors. This is also acknowledged by Duncan (2014) who states that recognising that farmers frame water quality issues differently to policy makers is vital for polices to be implemented.

4.3 Corridor Management after Implementation

The long-term aspects of managing riparian corridors after implementation have been addressed in only a limited capacity in the science literature and in the industry and policy documents. In New Zealand the focus has been on the commitment to weed and pest control in the two to three year period after establishment of planted areas (DairyNZ, 2014; Environment Canterbury, 2011b; Wellington Regional Council, 2001).

Internationally the issue has been looked at in a number of ways. Hale et al. (2011) suggest that an issue in management after implementation is the lack of long-term commitment to maintenance and "short-termism" associated with the timeframes given for ecosystem recovery. They also claim that failure can occur often even if short-term success occurs initially. It is noted that to fix this issue long-term support is required and should have the objective of both implementation and on-going maintenance. Reich et al. (2011) addressed the same issue identifying that this lack of long-term management is due to the short-term approach to funding of projects and an unrealistic view of the timeframes involved in ecosystem change. Burton & Paragahawewa (2011), indicate that for farmers to undertake long-term approaches environmental practices the actions need to be culturally

embedded in farming practice. They suggest this can only occur if the practice provides the view that in doing the action they become perceived as “good farmers” within their social networks.

Wevill and Florentine (2014) took a different approach by looking at riparian vegetation projects that had been established for over four years and looked at whether the intended objectives of the restoration had been achieved. The findings suggest that the amount of on-going maintenance required is relevant to the goals that are achieved.

Weed management is a particular issue associated with implementation according to Aarons et al. (2013). They also suggest that there is no data that quantifies the on-going management cost to farmers in the maintenance of fences. However Daigneault and McDonald (2012, p. 23) has indicated that in the New Zealand context, on a per farm basis the expected cost of annual stream fence maintenance is between “$1060 and $6400 with an average of $3400 per farm”.

4.4 Summary

This section has described the current documentary evidence of national and regional management of riparian corridors in agricultural landscapes. Overall the evidence is limited and fragmented and the main focus is on the implementation of stock exclusion from waterways, which has been shown to be variable. In Canterbury the most recent evidence suggests a high rate of implementation of stock exclusion; however it has been noted that the ability of these corridors to produce water quality outcomes is less than ideal. There is an obvious gap in the literature when it comes to the extent of vegetation implementation and corridor management overall.

Previous studies have identified key factors affecting implementation, with financial factors identified as one of the most influential. However the use of funding specifically has been identified as most effective when it is used to further implementation rather than initiate it. Other critical factors for implementation include the goals and objectives of policy, information, leadership, community and social factors, commitment from farmers, and the effect of farmers’ values and the importance of their perspectives to be realised for corridor design and management to achieve riparian function outcomes.

The literature suggests that management is focused on short-term components such as weed control in the initial years of vegetation implementation. The evidence suggests a lack of long-term management due to unrealistic time frames, the short-term nature of support and funding, and a weak connection between goals of design and management. It is recognised that for riparian functions to achieve water quality outcomes there needs to be long-term corridor management. However there is a gap in knowledge of the management of riparian corridors by farmers, specifically

in regards to understanding whether long-term management is occurring and the issues associated with it.

These observations raise the questions established as the objectives of this research. What are the experiences of Canterbury farmers in designing and managing fenced riparian areas? Does corridor design and management undertaken by farmers align with science literature, industry practice and wider policy? And what are the implications of these comparisons, what insight do they provide into farmers current design and management of corridors and how will they be useful in the future policy and practice? The next chapter establishes the interview and analysis methods used to answer these research questions.

Chapter 5

Interview and Analysis Methods

This chapter describes the research design and methods used to achieve the research goals. Section 5.1 describes the interview method and design. Section 5.2 outlines the method of data collection. Section 5.3 describes the data analysis, and section 5.4 summarises how the method will answer the research objectives.

5.1 Interview Method

In this research, personal interviews were conducted with key informants. These interviews provide an in-depth view of how farmers perceive riparian corridors, their experiences of design and implementation of riparian corridors, and management of the reconfigured corridors after implementation.

The design of the interviews was semi-structured, in which a number of pre-determined questions were designed to begin the discussion with the informant, which could then be expanded. This has the benefit of allowing the interviewer to probe further into topics raised by the informant beyond the initial question (Magnusson & Marecek, 2015). These follow up probing questions were not pre-determined but were asked during the interview based on the answer provided to the initial question, where the interviewer attempts to gather a further understanding of the answer given. Questions asked in the interviews conducted in this research began by establishing the interviewee's farming background, role and farm structure. The questions then went on to be focused upon topics such as the nature of their waterways, the corridor design and the management that they implement, with the use of probing questions to ensure that the research questions were thoroughly explored. Open-ended questions were chosen so that the interviewees could answer with whatever they believed was most important and express it in their own words (Silverman, 2010). The interview then ended with questions that considered the participant's overall experiences of stock exclusion and riparian corridor practices. Questions focused on what vegetation the informants had established within the riparian corridor, whether they managed the area behind the fence and how? Whether fencing the waterway provided them with benefits, if it was done because of regulatory or industry pressure, and if they would do it differently next time? Appendix A provides the interview guide.

The limitations of the semi-structured interview approach is in the time consuming analysis, meaning that the researcher is unable to replicate the process with large numbers of participants. The open ended approach also means that potential participants may not be willing to participate (inducing a

bias in terms of the type of farmer willing to be interviewed). Furthermore while the findings give an insight into farmers' experiences in corridor design and management, it is also important to note that farmers who were already engaged and responding positively to riparian design and management may have been more likely to agree to take part in the research. Additionally it is acknowledged that the information provided by the informants was to an "outsider" and this may have affected the responses given.

There is also potential for personal biases of the interviewer to unintentionally influence answers of interviewees (Creswell, 2009). To reduce this bias the interviewer needs to collect data with an awareness of their own understanding and preconceptions. To reduce bias in this research before beginning interviews I identified my own position in regards to the topic. I grew up on a sheep and beef farm in the Bay of Plenty which converted to a dairy farm when I was older. I value the outdoors, the environment and prior to undertaking this research I had completed papers towards a Masters in Water Resource Management and have the perception that riparian buffers are a step farmers can take to help achieve improved water quality. My interest is in the relationship between the farming culture and the environmental values. I conducted a pilot interview with two farmers from outside Canterbury which provided feedback on the method, and also identified possible personal bias (Silverman, 2010), and the questions were adjusted and my self-awareness sharpened.

5.2 Data Collection

Lincoln University ethics approval was granted before the participant selection and interview stage commenced. To satisfy the Health and Safety requirements the Lincoln University Human Ethics Committee [HEC] also gave approval for the use of a research assistant in order to meet health and safety considerations during field visits and interviews.

Purposive and snowball sampling methods were used to choose the informants. The use of purposive sampling means that the researcher selects informants in terms of the characteristics that meet the criteria of the research (Silverman, 2010). Snowball sampling involves asking informants to recommend further potential informants, as a way of identifying other interested parties and gain access to a broader set of perspectives and attitudes (Silverman, 2010). The literature indicates that dairy farmers are under pressure to exclude stock. Farmers who have established fencing for stock exclusion, and who have previously been surveyed about their riparian corridors (MAF stock exclusion survey, (Sanson & Baxter, 2011)) were judged to have sufficient experience and expertise in the implementation of riparian corridor techniques, and were chosen for the sample.

All 52 Canterbury farmers who participated in the 2011 MAF stock exclusion survey were initially sent a letter informing them of the research (letter is attached as Appendix B). The letters were

followed up by a telephone call seeking their agreement to participate. Seven farm who participated in the 2011 MAF stock exclusion survey agreed to be interviewed, and a further eight farms agreed to be interviewed through the use of the snowball sampling. The call was followed by an e-mail outlining the research in more detail and providing information related to ethics clearance (information sheet can be found in Appendix C). The information stated the research aims, its significance and the benefits, as well as the process of data collection and analysis. It explained how the recorded interviews were to be used and that anonymity and confidentiality of informants was to be maintained. All informants were reminded that participation in the interviews was voluntary.

Sample size was determined by saturation. This meant that the collection of data stopped when answers began to become repetitive, and when each new interview or changes to the type of informant that might influence the answers, for example, the types of waterways or the time farming added little new information. Fifteen in-depth interviews with dairy farmers were conducted between July and September of 2015 lasting a total of 60 minutes on average which in most cases included a visit to on-farm examples.

The sample was made up of a variety of informants. The age of informants ranged from early 30's to late 70's, the average time interviewees had been dairy farming was 34 years, almost all were male with three female informants. In some cases the informants responded as a couple counting as one interview. Only one informant was a supervisor of the farm and all of the other informants were owners of the farms. The farm size, herd size and length of time dairy farming of each informant is given in the table below (Table 5.1), the largest farm with approximately 3000 cows and the smallest 70 cows.

Size (hectares)	Herd size (no. cows)	Time dairy farming (years)	Landscape type	Fenced or planted corridors	Informant
130	no data	34	Foot hills	Planted	F5
200	660	25	Inland basin	Planted	F1
250	60-70	70	Foot hills	Planted	F7
267	840	44	Inland basin	Planted	F8
300	1400	15	Central Plains	Fenced	F6
318	650-670	50	Lowland Plains	Planted	F2
320	1000	50	Lowland Plains	Planted	F12
440	650-1100	76	Lowland Plains	Planted	F4
580	1520	7	Central Plains	Planted	F9
1000	3000	10	Central Plains	Fenced	F3
1026	700-750	23	Inland basin	Planted	F11
170/128	505/369	10	Inland basin	Fenced	F14
170/400	1400	48	Foot hills	Fenced	F10
630/210	1540/630	22	Inland basin	Planted	F15
no data	no data	20	Inland basin	Planted	F13

Table 5.1 Summary of informant's herd and farm size, time dairy farming, landscape type and corridor type.

All of the informants except for one were pastoral dairy farmers. The number of waterways on the informants' properties ranged from one to twelve with an average of three and the length total on each farm varied from one kilometre to over eight kilometres. The type of waterways included both natural, manmade, and ephemeral waterways, and the location of the farms were a mix of three Canterbury landscapes lowland plains, inland basins and foothills. The key criteria being that stock exclusion, as a minimum form of riparian design and management, had been implemented. The estimated average time since implementation of fencing was 8 to 9 years (this time being an estimate due to the often-vague approximations given by interviewees). This is a diverse range for a relatively small sample, indicating the selection of informants had been effective.

The interviews took place face to face and in a situation that was comfortable for the informants at the farmer's office or home or where on-farm examples could be shown. Most of the interviews consisted of two parts; beginning with semi-structured questions and then if convenient an on-farm tour where examples could clarify information given in the first part. The interviews were recorded, and notes were taken. The recordings then were transcribed and analysed. Most interviewees did not take up the opportunity to review or verify copies of the transcripts. An example of the consent form can be found in Appendix D.

Anonymity was achieved by using codes to label the data, and then maintaining a separate and secure list linking the codes to the names of informants. When data is reported, only aggregate analysed data is presented so that they cannot be linked back to individual informants. The informants are referred to in Chapter 6 according to their code to maintain anonymity. The letter F and a number between 1 and 15 make up the code for each interview, within an interview conducted with a couple each interviewee was assigned a letter "a" or "b" based on the person who spoke first. In addition, sections of quotes or information that could reveal the identity of the respondent were removed and replaced with "…" or with "[more general information]".

5.3 Data Analysis

The transcribed data has been interpreted using inductive methods of analysis to identify key themes that describe and explain the management of riparian corridors. Coding and memos were used to identify themes from the data and the thematic analysis distinguished the patterns that exist in the dairy farmers' experiences (Schreier, 2014). The significance of a theme was determined through content analysis, which considered both the substantive themes expressed by informants, and the frequency with which particular themes were expressed by an individual and by the group overall (Schreier, 2014). This was to determine the patterns among the farmer informants about significant experiences. Content analysis involved steps of building a coding frame, trial coding, evaluating and modifying coding frame and using codes to analyse transcripts (Schreier, 2014).

In addition each quote that provided evidence for a theme was constantly revisited, where it was questioned to determine if it was still relevant or if it fitted better under a different theme. Repeated analysis of the data was done using NVivo as well as manually pulling out the themes and sub themes of related information. NVivo was used as a software that provided functions which helped in the thematic analysis, for coding of data and comparing themes between transcripts (Gibbs, 2014). Themes were categorised under 'design' and 'management' headings to answer the research questions (Schreier, 2014). Once the themes were clearly arranged under headings they were compared to policy and industry initiatives to determine consistency.

Frequency indications help to determine the number of instances of a particular theme and the distribution of the theme among informants. Maxwell and Chmiel (2014) indicate that this strategy is used to support internal generalisation of results. The purposeful use of frequency allows the researcher to assess the amount of evidence in the data and gives support to the rareness or prevalence of a particular theme (Maxwell & Chmiel, 2014). However due to the small number of interviews I have used a basic nominal measure to describe themes in Chapters 6. This measure is used to avoid giving the specific number or percentage of informants associated to a theme. This is a study that looks to gain insight into the experience of farmers rather than determine a specific quantity of farmers that share a perspective. It would be misleading to give a specific proportion to any given theme. The nominal measure has been used as follows; *minority* shows one to six informants had that view, *half* indicates approximately seven to eight, a *majority* is between nine and fourteen and *all* means all fifteen informant interviews indicated the theme

The use of frequency as a strategy for generalisation was combined with a narrative analysis where the relative importance of a theme or sub theme to an interviewee was established. Themes are identified by how the speaker makes a point, by using language that emphasises the significance of a topic to the interviewer (Riessman, 2008, 2012). For example, the importance of an opinion an interviewee expressed was indicated by their descriptive language *"I think that riparian planting makes a huge amount of sense" (F1).* In this example F1 identifies that riparian planting makes a "huge amount" of sense, the addition of *huge amount* to his sentence shows the significance of the action.

5.4 Summary

This chapter described the interview method of semi-structured in-depth interviews, the sample and the protocols followed. It has also explained the method of analysis, using content and narrative analysis to determine themes and significance of the findings. The research uses a qualitative interpretive strategy to address the research questions established from the literature. The next chapter describes the experience of farmers in the design and management of riparian corridors.

Chapter 6

Findings

This chapter reports the findings in terms of the informants' experiences in both corridor design and management. Section 6.1 reports on how informants design their riparian corridors. Section 6.2 reports on how informants manage their corridors following implementation of their designs. Section 6.3 examines the factors informants identified that contributed to the success of their designs and management techniques, and section 6.4 provides some overall observations. Section 6.5 compares the informants' corridor design to their expressed management. Section 6.6 is a summary of the chapter.

6.1 Corridor Design

As defined in section 1.3.3 corridor design actions refer to the experiences that informants report as part of the planning, designing and implementation of riparian corridors, the action is what they have done in terms of corridor design. The findings indicated that riparian corridor design can be broken into four categories: the rationale for taking action, the priorities for action, the type of action and how actions are evaluated.

6.1.1 Rationale for Design Action

There are four reasons for the implemention of fencing or planting riparian corridors identified by informants. The two main reasons were water quality and aesthetics. The secondary rationale for riparian designs was the need to provide for stock well being, and to avoid or comply with regulation from both the companies they supply to and regional authorities.

The majority of informants expressed water quality issues as prime reasons for designing their riparian corridors to exclude stock or be planted. This was because they believed the water quality issues could be remedied by these actions. As one informant explained:

> *"I think it [stock exclusion] is one of the only effective tools, without that you can't effectively manage water quality, without a buffer strip, and vegetation really helps yep" (F1).*

When F15a and F15b were asked why they implemented a certain corridor design, they said they did it to improve the health of the land they owned, particularly that of water quality:

> *"I guess, endeavour to leave the environment better than we found it so doing things like this is not a bad thing" (F15a).*
> *"Yeah, well hopefully just keeping the water clean I mean that's pretty important." (F15b).*

Some of the informants said that awareness of dairy impacts prompted them to restore their riparian corridors, particularly problems related to excessive nutrients, erosion and sediment:

"So to try and um alleviate the phosphate into the river, we fenced off" (F11a).

"having animals kept out you know there's a lot of, where they tread in soft spots you know there's a lot of erosion problems and silting and so on, particularly in wetter weather" (F8).

Aesthetics was a second main reason a majority of informants chose to implement their riparian designs. The aesthetics of the corridor appeared to be of equal concern as water quality. Informants wanted their corridors to "look good":

"It looked good that was one of the reasons… right from the word go, it looked good, so we thought, well we'll just keep doing this." (F4).

Half the informants wanted to show they were doing what was "right", and to have the public make note of this when they viewed their corridors. The informants expressed that they wanted them to be considered attractive and well looked after, to show they were taking care of the waterways:

"we have to be mindful that we are custodians of the land and that, that for the uneducated people, the city folk driving past can see that it is being well looked after. You know so there's a bit of image involved" (F11a).

Informants prioritized planting the areas of their waterways that were highly visible from roadsides:

"…we started right up the end near the road right in the corner there where everyone could see it. And it looked good" (F4).

Figure 6.1 shows two different examples of farmer corridor designs. Both plantings were located in highly visible areas next to roads.

Figure 6.1 Two different examples of roadside riparian corridors that have been designed to be noticed by the public. The reason for this corridor design was to show they cared for the waterway by making it aesthetically pleasing. (A. Mark, 2015)

Half of informants who listed the aesthetic functions of their plantings as one of multiple reasons for implementation suggested that their own pleasure and that of their family was part of their aesthetic values:

> *"But the other thing is that I live here with my kids too, this is my home and we want it to look nice" (F1).*

> *"But yeah aesthetics too, we like nice surrounds" (F5).*

Half of the informants also wanted to demonstrate their care or stewardship of the land. This rationale was about demonstrating the role famers play in managing the land. Informants were implementing corridor design actions because they saw it their responsibility to care for the land and accepted it. Aesthetic values were associated with this responsibility. The rationale was the corridor design and waterways "look good" to indicate to *them* that their actions were valid:

> *"The benefits are around [the staff] feeling good about it. And it's about license to farm you know that moral license to farm and that we are looking after the environment." (F1)*

> *"I'm not worried about people, I'm more worried about how I look upon my farming and I try to do a good job" (F8).*

> *"oh, you got to just look at yourself in the mirror don't you, you can't say well we're not going to do anything because the neighbours aren't" (F15b).*

Another identified:

> *"…there is a feel good factor of saying yup we're doing it" (F2).*

Half of the informants also indicated they designed their corridors to ensure stock wellbeing. This reason had three sub themes. Some informants wanted to prevent stock from drinking from the waterways. They preferred the cows to drink from the trough systems which contained supplements such as magnesium:

> *"Especially with the cows you don't want them drinking that water because you want them drinking water with the mag [magnesium] and the things in or they get milk fever and fall over. So you don't really want them drinking out of the water race." (F3b).*

Other informants wanted to keep stock safe and prevent them from getting stuck in the waterway:

> *"the fact that [with] the stock going in the creeks, that the dangers for the animal get stuck and not coming out that is a problem because there is no gravel underneath it's just going to sink away and not coming out and they drowned that happened sometimes in a year" (F7).*

Finally, some designed their corridors to shelter their stock from adverse microclimatic conditions:

> *"Stock shelter is pretty important. Cows are pretty like us they would be in here [the house] if they had a choice." (F8).*

Lastly, a minority of informants said they designed their corridors because regulations required them to. Some said they felt they had to comply:

> *"Um basically, we are not allowed to go in them anymore so they are all fenced off… Basically to be compliant" (F6).*

Others said they wanted to take action first rather than risk being labelled as non-compliant or a poor farmer because they did not respond to societal concerns:

> *"…social laws and values are shifting to a point. So you either lead that, and get in front of the game or you get trapped in a space where you have to catch up... So just getting in front of the game, being a leader, understanding what has to happen, don't necessarily have to agree with it too. So no I'm not the great environmental leader it's just that, that's where society's taking us…" (F2).*

The rationale for riparian corridor design actions, identified by the informants, is led by the impact of dairy farming on water quality and aesthetic values associated with both outsiders and personal opinions. The secondary reasons are for stock wellbeing and managing the risk of further regulation. Whether these rationales align with the current science and the expectations of best practice and wider policy can be examined to determine how well actions meet functions, and goals of corridor design. Informants also identified that they wanted to do what is "right", identifying that they are doing what is most socially acceptable however the ecological value of this view needs to be questioned.

6.1.2 Priorities of Design Action

Priorities of the actions informants were taking in corridor design were based on five different themes. The two main priorities identified by the majority of informants once they had chosen to act were the exclusion of stock and the values of different waterways types. The lesser themes were around plant biodiversity and providing for nutrient inputs into the waterways.

The majority of informants expressed stock exclusion as a priority in corridor design actions. The extent to which stock exclusion was a priority on each farm varied very little. For the most part all waterways excluded stock through fencing. This included all waterway types from natural, ephemeral to manmade:

> *"All of them are fenced, all of the drains and water races are fenced and they have been fenced for years…" (F3b).*

> *"A lot of the drains, probably 90% of the drains, even though they are not flowing drains they are still fenced." (F4).*

Figure 6.2 is an example of how stock exclusion is the priority of action for all types of waterways; the image shows a permanently fenced ephemeral drain to exclude stock.

Figure 6.2 An ephemeral drain that has been fenced to exclude stock despite the absence of water. The priority is stock exclusion of all types of waterways. (A. Mark, 2015)

It was clear that fencing to exclude stock had long become an accepted practice among the informants. Stock exclusion was recognised as "a given" in dairy farming, it would be frowned upon if the waterways were not fenced:

> *"…we've fenced off, to be honest it was already fenced off when it was a deer farm. Um it just never even occurred to me, not to have it fenced off, stock exclusions its best practice you know irrespective of any regulation." (F14).*

> *"Actually as a dairy farmer it's really frustrating, you see these images on TV and you're just like 'oh god put some fences up, get ya cows out of the drains.' It's just stupid." (F3a).*

Beyond stock exclusion, informants indicated that they had different riparian corridor designs depending on whether waterways were manmade streams, natural waterways, drains or stockwater races. The type of waterway was a consideration in determining action, as the values and requirements for riparian design of one waterway type differed from another:

> *"…I guess some consideration… all waterways are different and flood zones and erosion… it's not so much an issue on a smaller creek, effectively, but um some of our larger rivers, erosion and river bank control is a bigger part of that, riparian management is necessary." (F14.)*

Informants prioritised waterways or areas where water quality was most at risk and left areas of least risk until last. For example, areas of high nutrient loss were targeted first:

> *"…concentrate on what's the hotspot or the clean-up point. Rather than planting the whole thing." (F2).*

Another farmer explained that if an area was not used often, it was dealt with last:

> *"[The last waterways] were only really, [in] small paddocks and they were only used for really sick cows, and bulls and that sort of thing. So we never had the herd going in them anyway" (F5).*

Half of informants prioritised actions that increased the diversity of plant types in their riparian margins. Informants wanted to increase the diversity of plants within their pasture-based monoculture. They identified riparian corridors as a place where they could do this. The purposeful application of plants that diversify the environment and bring in the bees and birds was noted:

> *"…diversity of animal life is a good thing. You know, dairying is one big ugly monoculture really you know rye grass is a fairly boring plant, and that's, that's just the business. And you know there's value in birds and bees… And we've put in plants around food sources for birds and stuff like that too and you know we've done a bit of research on that to try and diversify the environment" (F1).*

> *"…the sort of thought is there to try and get New Zealand natives back into… Canterbury. There are patches but not many" (F8).*

The function of the riparian corridor for filtering nutrients was a priority in design for a minority of informants. Informants designed an un-grazed buffer of grass to reduce nutrient and erosion inputs:

> *"I think it's all good if it's just grass, I think environmentally I think just grass is possibly as good as anything if you want to stop nutrients getting in. They're probably better actually" (F13).*

Plants that take up nutrients and have a large root system to stabilise banks and reduce the loss of phosphorus through erosion were also included in this buffer:

> *"But it is very strongly flaxes and carexs because they are very good at absorbing nutrient, you know, [have a] big root mass" (F1).*

> *"The grasses and what have you, the carex and what have you, they're very good at filtering, so the right plant in the right place I guess. Yeah. Like a tree in the middle of a hollow's not going to do a hell of a lot but you plant the hollow out with grasses it will filter and yeah take some nitrogen out and slow the sediment" (F11a).*

The priorities of action are connected to the two main rationales for water quality and stock wellbeing. The informants prioritise actions which provide functions for nutrients and diversity of plant life and are focused on the values associated with the waterways themselves. These priorities raise questions about why the provision of functions that relate to aquatic habitat and recreation are not included and by what means the values given to the informants' waterways are determined.

6.1.3 Type of Design Action

Two levels to the type of action taken in corridor design were apparent. The first level was the Farm Environment Plan (FEP) which provided the context for the second level which was the specific actions taken. These specific actions were determined by fence implementation, type of vegetation, and form of access to the corridor needed.

Farm Environmental Plans

FEPs are becoming a mandatory document for farms with a high risk of nutrient leaching. In Canterbury, farmers must have an FEP under the new rules of the LWRP (2015). A minority of the informants already had a FEP in place. The function of the FEP is to help farmers recognise the environmental risks unique to their property. The FEPs try to implement multiple approaches for land management to mitigate environmental impacts. A whole farm management approach is important in combination with riparian corridor design. One farmer informant explained:

> *"Yeah I think you know on some of these lowland intensively stocked paddocks it's probably grazing management try and stop the soil moving across the paddock to start with that's probably got the biggest impact [on water quality] and then the ambulance at the bottom of the cliff is the bit of planting in the creek. And that's what all these farm environment plans [are about] and all that we are starting to do now." (F11a).*

For riparian design, FEPs require farmers to outline the waterways on their farms, the existing riparian designs and the new riparian designs for future implementation. As a result, an FEP was an important tool that personalises the implementation of design and planning for riparian corridor actions. The informants noted how it helped them in their implementation of corridor design:

> *"So this articulates what I want to achieve and the farm environment plan itself is about my management, my system and me identifying the risks on the farm and then putting in place mitigations" (F2).*

The specific type of action taken could be divided into three major themes: the width of the riparian margin, the type of vegetation, and access to the margin.

The width of the riparian buffer

The width of the riparian margin, and particularly the distance between the stream edge and the fence was important for a majority of informants. When implementing fencing the informants used five criteria to decide where to put the fence, and the width of the riparian margin. There was no clear consensus among informants regarding which criteria was most important.

Most commonly informants identified a straight fence as ideal. This meant the farmer put the fence down either side of the waterway, with variable widths in the riparian buffer depending on the way

the stream moved in between the straight fence (as shown in Figure 6.3). This was articulated by one informant when asked about the width of their riparian margins:

> *"Yeah so there's places that'll be a lot more, a lot wider margins than others a bit farther, it's just a case of reducing as many corners as possible in your fence" (F14).*

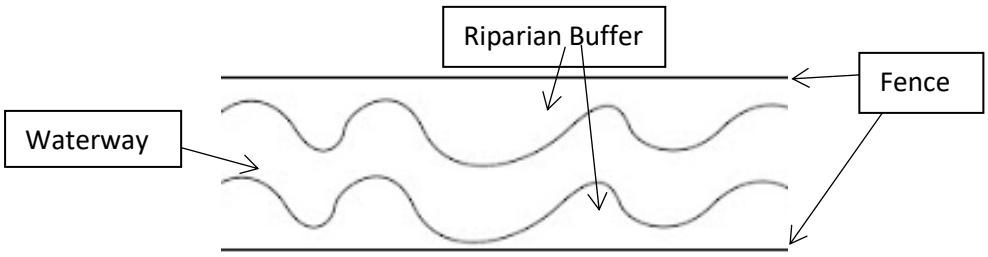

Figure 6.3 Image showing the variable widths of a riparian buffer when a straight fence next to a meandering waterway is implemented.

The width of the buffer was also determined by a desire to retain as much pasture as possible:

> *"We're pretty happy like we don't want to waste too much land fencing it off." (F12).*

The geography of the land also dictated fence placement. Natural landforms, sloped, and wetter areas were all factors of consideration when informants decided where to place fencing. For example, one farmer explained how a slope needs a wider buffer than flat land due to the higher chance of runoff:

> *"as we've gone on, we've learnt that, you know, that through a gully you need a bigger space so that it can actually filter the runoff water before it enters the waterway" (F11a).*

Another condition for fence placement was a desire to achieve a tidy appearance. A few of the informants decided that the closer the fence to the stream the less mess:

> *"Um no we haven't really allowed for a buffer zone it was, sort of attempting to get as close to the waterway, within reason. Mainly I guess, I'm not too sure if that's the right thing for the environment, but for a sort of tidiness of them, I sort of like to get them as close to the water as possible. So they are about a metre off the waterway I guess." (F9).*

Figure 6.4 Picture showing the fencing of a drain with a narrow buffer width, where the criteria used by the informant was to keep the corridor looking as tidy as possible. (A. Mark, 2015)

Figure 6.4 is an example where one farmer fenced as close to an ephemeral drain as possible to minimise loss of land and keep grazing pressure right to the edge of the drain to achieve a tidy appearance.

Finally, the width also needed to provide for the amount of planting that was going to be implemented in the future. One farmer informant describes:

> *"Yeah, and we've gradually got wider… So it's no good having a metre, your fence a metre off the stream bank if you're going to plant a 3 metre flax bush" (F11a).*

The type of vegetation

A majority of informants used plants purposely to address their priorities for action and the type of action involved a targeted approach. This meant that not many of the informants had waterways with the riparian corridors planted along the full length:

> *"We've done all the really sensitive areas, like because we've planted from you know there down to there [waterways on the map]. And you can see how wide we've got here so any, any runoff from this property has to go through that wet land, yeah. So, you know, although we've [still] got to plant from here up to there, it'll have, won't have as much impact on the environment" (F11a).*

Plants in these targeted areas were chosen based on whether they would survive the region's conditions:

> *"… [the problem] people have is the wrong plants in the wrong place, and getting good advice and getting good plant stock is the key. It is really frustrating when the bloody things die on ya, and in the past I have had that issue so I have been very careful to get good plants"(F1).*

Central pivot irrigators also determined the type of action and it was mentioned by half of the informants as something that influenced the planting of riparian corridors. Tall vegetation was less desirable in these circumstances:

> *"Um, we sort of had to like we couldn't put tall plants on this side of the road because the pivot goes over the top of the drain… [we] just stipulated that we couldn't have tall ones down here" (F12).*

Access also determined the type of the riparian design. A majority of informants said they needed access to the corridor for both stream cleaning and emergency stock water. Certain waterways within Canterbury catchments are required to be cleaned by farmers so that flow is maintained for downstream users. This is particularly true for farmers who have stockwater races for which they must pay rates for the race to flow. Farm drains are also important in keeping the land drained in the lowland plains. Each of these waterways needs to be cleaned out occasionally. Other waterways are cleaned when they are not draining properly to avoid flooding and pugging of paddocks. Drain clearance involves a digger clearing the waterways and disposing of the cleanings on the side of the streams or in the adjacent paddock. Of the informants who fenced and planted their waterways, most identified the consideration of their ability to reach a digger arm over the fence and into the stream from a roadway. This determined the width of the riparian margin, and led to a thin riparian margin on at least one side of the corridor, planted with low-lying plants that did not interfere with the digger arm:

> *"Then if you talk about a 3 metre or a 5 metre width how do you get over it to clean?… If the cleaner, the digger, has to sit back here to try and, he just physically can't get, reach over to clean." (F2).*

Some informants achieved this through planting only one side of the corridor and designing the other strictly for digger access:

> *"Yeah, one side, keep one side clean, open to work. And the other side you can have a bit of lay back and shrubbery on the side." (F10)*

However design still needs careful consideration, information and planning as some waterways have special requirements:

> *"… [The waterway] has to be cleaned out, which they've just done. And to be fair that is, we got some sort of kick back from the irrigation company and the regional council about the plantings….Yeah cos it meant that they couldn't, they needed a bigger machine to clean them out from the farm side to reach right over. And they weren't keen on them getting over 2 metres in height, which they aren't at that now but the will do." (F9).*

Half of the informants also designed their corridors to allow for the emergency access of stock for water in the event that trough systems failed:

"The other thing is that occasionally the pump stops so there's no stock water and I've got to pull a wire back to let the cows in yeah so they're the only two reasons for access" (F10).

The two levels in the type of design action taken are firstly the use of FEPs to determine action and then the specific way in which an action is implemented. The type of actions the informants were implementing and the level of action raises questions about how information on buffer width is interpreted by informants and the effectiveness of their targeted approaches to plant implementation.

6.1.4 Evaluation of Design Action

The majority of informants evaluated the extent to which their riparian corridors met their needs. The method of evaluating was most often a visual inspection. Other types of evaluation included whether they gained recognition for their efforts and the results of monitoring on the water quality in their waterways. While informants wanted to know whether their design met intended functions, the majority of informants did not monitor their corridor functions. One informant explained:

"Well I haven't had it tested or anything I guess …yeah I would like to see scientific testing done. Sort of, having some figures to look at." (F8).

Therefore informants used subjectively determined evaluations, based on what looked good to them, to determine the effectiveness of both vegetation and fencing. For example when one farmer was asked how he decided what plants to be put in he replied:

"Oh it's the ones that make it look attractive really yeah." (F13).

This form of evaluation could have been used most because "looking good" was based on a visual assessment. An aspect of this was the death of plants, which could be visually assessed and was cited as an obvious indicator of failure or success:

"One lot I did last spring that I sprayed out and I went and had a look…but yeah there is probably only 10 % of them alive now" (F5).

"We tried planting some stuff there but only about a 3rd of it came up." (F12).

Recognition from the public and industry played a role in how a minority of informants evaluated the success of their corridor designs. Some received positive feedback from community members:

"…oh the amount of positive feedback we've had about that planting has just been amazing really… so you know like just if you meet someone in the community and they ask where you farm and they know anything about farming and you say oh well we're just on [the] road with all the native plantings and they're like oh yeah!" (F9).

Others had been given awards from Environment Canterbury or the industry which acknowledged what they had achieved:

"There's a cup up there on the wall that we won…for planting... Yeah so it's quite a thing." (F4).

While a few felt that even though the regional council had recognised their efforts, the public had not. They did not think their planting had contributed to an improving public perception of their farm:

"And um it doesn't seem to be reported very widely but we did win the um top community award from ECan, it wasn't even reported in the papers." (F13).

A minority of informants used monitoring to evaluate their corridor design actions. Often this was done by external parties such as Environment Canterbury or tertiary institutes. Some informants had been provided proof of achievement through monitoring of the waterways quality:

"he said that [the waterway] is internationally famous now because it's on an international website because of the work that's been done on it with research at the university and water quality has improved so much…" (F4).

The main way of evaluating the success of riparian corridor design was through a visual evaluation of aesthetic appeal. While informants wanted scientific monitoring to be done, they often had no access to it. The way in which the informants evaluated their riparian corridors could have consequences for the effectiveness of the design to provide functions, and suggests that monitoring could be improved to offer informants a better understanding of corridor design outcomes.

6.2 Corridor Management

The way in which informants are managing riparian corridors over time after implementation of corridor design actions is shown in the findings below. When informants were asked how they managed the riparian corridor after they had implemented the design, they all defined it in terms of maintenance.

6.2.1 Farmer Rationale for Management

Only half of informants outlined what they were hoping to achieve through management, yet all of them identified some management practices. The minority of informants that mentioned the reason for their management practices said they managed for aesthetics, containment of weeds and maintaining the flow of their waterways.

Enhanced aesthetics was mentioned as a very important reason for management. For some of the informants, having their farm look nice was important, and maintaining a tidy or aesthetically pleasing riparian corridor was an important part of this. The aesthetic needs of informants who had only fenced their waterways was reflected in the need to achieve "no mess" and a reason to manage the corridor was to keep it tidy. The informants with this view indicated that to have long grass and

weeds in their riparian corridors were untidy. This reflects the idea of Nassauer (2011) of 'cues for care'. As one farmer commented:

> *"…I mean I can let the grass grow but it just looks rubbishy, I suppose it's not in anyone's way but sometimes you want some areas to be a little bit aesthetically pleasing." (F6).*

The other reason for management was to contain the weeds. The spread of weeds across the farm was undesirable. Therefore a priority for corridor management was to contain the weeds and reduce their spread:

> *"Yeah, and just to limit the spread of the weeds. I mean if you get 20 flowering thistles then next year you get 200." (F6).*

> *"Well I mean weeds a weed you've got to contain them as soon as you've got any weeds growing anywhere you know they become a contaminant source for the rest of the farm" (F14).*

Informants' reasons for management also included the maintenance of flow in the waterway. The informants identified that if the flow of some waterways was not maintained, flooding of their farm was more likely and wet patches increased, which degraded pastures through pugging:

> *"There is a lot of that um I dunno that green weed that grows in [the waterway], and you get a big rain fall event up in the hills and all the water comes down and it just grabs all this weed and it just blocks all your culverts and you got water going everywhere" (F5).*

The rationale and priorities for management actions identified by informants were based on aspects that related to the issues created by implementation and design. The aesthetics, flow of the waterway and preventing weeds from spreading are the priorities and reasons informants cited to manage their corridors. However the low number of informants which identified a reason for management raises questions about their understanding of management and the connection between the aesthetic priorities and water quality variables.

6.2.2 Type of Management Actions

The types of action taken in terms of corridor management comprised weed management, plant maintenance, stream cleaning and fence maintenance.

Weed management was important for all of the informants. The purpose was to maintain desired plants, contain the spread of weeds on-farm, and for aesthetic and increase the tidy appearance of the riparian margin:

> *"Um currently we are just spraying out the weeds that come though, thistles, gorse or broom. And the grass… to be honest we are little bit unsure on how to, or what to do with it. We can't really get in there with a mower or anything to keep it short but yeah." (F6).*

In terms of weed management, killing the weeds had to be performed in ways that did not result in all the plants dying:

> *"Well it's hard to, see for example that blackberry bush how do you spray that black berry bush without killing the flax?... well you imagine going through chopping it, I will come through spray some of that stuff out, but maybe we won't maybe we let the other stuff get up above it…it's probably not doing any harm but the problem is once you've got some blackberry you just get more of it you know" (F13).*

This meant that weed removal became a key management action. The majority of informants indicated that to maintain the riparian corridor, spraying to kill the weeds was the most useful. However, they said care had to be taken not to kill the desirable plants as well, and to avoid spraying chemicals into the waterway. Compared to the other options of weed removal it was easy to implement and effective in killing weeds quickly:

> *"you start using Round Up round trees willy-nilly and then half of them will die cos it just bowls everything so yeah you've got to use things like um Galant which is solely a grass killer, and we have been using combinations of Galant and Versatil which kills the flat weeds but yeah you've still got to be careful round them and you've got to have a perfectly still day really otherwise your wasting your time, well yeah you end up killing them and you wonder why you were planting them in the first place" (F5).*

In most cases where manual removal of weeds occurred it was in combination with spraying, where the plants are released manually by physically pulling the grass or weeds away from the plantings and then the weeds were sprayed:

> *"Yeah go through with a hoe or a spade or something and release the plant and then you can spray round them a bit mm" (F11a)*

Half of the total informants used external contracted maintenance companies to manage their riparian corridors. For the informants that implemented vegetation into the riparian corridor the use of these companies was common:

> *"Oh yeah, yeah cos sometimes you get so busy just chasing cows and trying to keep the cows alive that you know going and looking at a few flax bushes down the creek is the last thing (F11b).*
> *"You wanna get home. Cos it is as I said that was our mistake here in that we didn't get [the contracted nurseryman] to keep some, I've actually been looking at it as I've been driving past, he'll go down and spray it, yeah [contracted nurseryman]'s good like that just comes out" (F11a).*

Just under half of the informants said they maintained newly planted riparian vegetation. Informants saw value in maintaining plants carefully during this time to prevent them from dying. They wanted to avoid having to replant:

> *"…because the early maintenance is pretty intensive. Just got to keep control of the weeds, cos once they get smothered that's it they're gone." (F4).*

"Yeah it is a load of work yeah, but you need to, like I say that one along [the] road we spent 30 grand on it and we have to look, like I have to look after it otherwise like if we didn't maintain it, you know the grass would get around all these little native plants and it would be almost like a, you could lose half of them which would be a waste of money to be perfectly honest" (F9)

Some of the informants with plantings noted the importance of ensuring new plants were irrigated:

"So the ones we planted 12 months ago just absolutely phenomenal they were wetter and had really good irrigation as well and just amazing how in the right environment they can really grow" (F2).

Some had even gone as far as implementing irrigation solely for the vegetation, rather than relying on pasture irrigators to water plants:

"To be fair when we put it in we didn't put a drip line in with it. And we thought we were going to be able to catch it, catch the watering of them with the irrigator but that didn't really work so we put the drip line in oh probably when they were 3 years old. And it sort of made it, getting it established for the first 3 years a wee bit more difficult because in those growth periods they, you know, in a good warm growth period they were lacking moisture so once we've put the drip line in they've come away" (F9).

Stream cleaning was the other type of management action half the informants used to maintain the flow of the waterways. It was one of the ways to remove the unwanted aquatic vegetation that was choking the waterway. One informant claimed:

"I just see mechanical clearance as a simpler um solution." (F10).

As shown in the previous sections, stream cleaning was considered in the design of the corridor so that the ability to do it when managing the corridor was available.

Fence maintenance was only mentioned by a minority of informants. One farmer said he maintained his fences frequently as the irrigator which crossed his waterways, continued to get caught in the wire. Although this was a problem not isolated to the fences near waterways:

"We have to maintain them all the time because they've got pivots going across them," (F3b).

However, this farmer didn't think frequently repairing his fences was a significant problem,

"I think you just see it as part of it, it has to be done really" (F3a).

Another farmer indicated repairing fencing was not a significant added cost. It was viewed as a standard farming task to keep stock out of the waterways:

"Just a bit of extra fencing to maintain. But like I say that's just a fixed cost" (F10)

The types of management action informants used focused on aspects of weed management and stream cleaning. This focus raises questions about the ability of management to meet the rationale and priorities identified for design.

6.3 Key Factors Influencing Farmer Design and Management

There were some clear factors identified by informants for both corridor design and management actions to be a success. These are divided into four key factors: means, external pressure, access to information and ease of implementation.

6.3.1 Means

There were three aspects that contributed to means as a factor that influenced success. Firstly financial means was important, and informants identified that implementation depended upon the availability of funding:

> *"There's been an opportunity to go into [planting] because the money's been much better. But previous to that dairy farming was pretty terrible and there wasn't any money for that sort of stuff so because of the financial… I dunno if you call it windfall, the dairying [has] certainly been much better in the last 10 or 15 years than ever in my whole career so there has been money available to address those issues" (F1).*

If informants had a poor financial year, they often did not implement riparian restoration:

> *"But yes I've seen farms that have done it and it looks good. Um suppose in a pay-out year like this we're not quite going to spend money on pretty plants." (F6).*

The ability to apply for and receive funding from outside sources was cited as an enabler. It helped them overcome a low pay-out situation:

> *" certainly in the current fiscal environment with the pay-out being as pretty shit house as it is it's …yeah it's not just a put your hand out here's some money" (F15a).*
> *"It's more just a small amount compared to what the farm has actually spent yeah, but it's anything is better than nothing, so it's still worth having" (F15b).*

As part of this financial dimension, the loss of land used for production was also a deterrent to planting. The main issue was the loss of pastureland that could support another cow, and thus income:

> *"It takes out land I could have a cow on, that I have paid for and I am not going to get a dollar return on it. So it is taking out I dunno a couple of hectares which would be 6 or 7 cows so there is a financial cost to the business in doing it. I don't think [planting] makes me money but in saying that it will in capital value. If we didn't do it the capital value would be down so I guess it is quite a lot of money but it doesn't make me cash though is what I am saying. 25 years ago you would fence every creek right to the edge and get as much grass as you could." (F1).*

The high cost of management also was expressed as a barrier to implementation. Most of the informants mentioned there was a cost to managing their riparian corridors after implementation, in both money and time. As one informant explained:

> *"Just that times a bit tight currently anyway and they have been in the past also. It's a bit hard being a superman too. Huge demand on time and energy really" (F8).*

One farmer identified the management of weeds as a significant financial cost:

> *"Throw a lot of money at weeds. Weeds get out of control it goes from a little job to quite a big job quite quickly which gets quite expensive so" (F14)*

Another expressed the time it took to manage his corridors as significant:

> *"So you've really got to spend I suppose a lot more time and money on, it's not just in buying the plants, it's looking after them and whether you got the time to do it or not… Yeah, it's just that it's quite expensive to get it well expensive in monetary terms and in time to get it looking like that" (F5).*

In fact, all informants indicated they spent significant amounts of time and money managing their riparian corridors (especially plantings), both at the beginning of establishment and after they have been established:

> *"People just say 'oh fence it off and plant natives', but it's actually not quite as simple as that… that's the number one biggest thing, the planting of it… I think you've just got to be aware of what happens when, you know, and it takes a lot of maintenance." (F13).*

Means as an influential factor in riparian corridor design and management has many sides. Access to financial means, whether it is funded personally or from outside parties, raises questions about the ability and the willingness of informants to manage and implement riparian corridors appropriately. Having the means in relation to time was also identified as significant as well as time to implement initially as well as manage the corridor. These aspects could indicate the need for long-term support for management from outside parties and raises questions about the effectiveness of existing support.

6.3.2 External Pressure

Pressure proved to be important in motivating informants to take action. Pressure to commit and conform to implementing riparian design was identified by the majority of the informants. This pressure was in three main forms: pressure created by regulation, their peers and the public.

Informants saw regulation as a form of pressure to implement corridor design because it was a reason to do it, motivating them using the "stick" rather than the "carrot". The threat of not having

their milk picked up was motivating to some and was seen as a good way to ensure others were also doing the same as them:

> *"yeah I mean that's another carrot, well not a carrot that's another stick they can beat us with they won't pick our milk up if we don't do as they, you know be the good boy scouts and you know I don't disagree with that." (F15b).*

The pressure from peers was typically created through the involvement in community groups that were established to deal with local water quality issues. Seeing the results of the implementation was indicated by the informants as a positive of these groups:

> *"…we took some sort of responsibility for what that looked like and um since we set that [group up] there's been continuous decline if phosphate and nitrogen going in from the [tributary] river into the [main river]" (F13).*

> *"One of those creeks further down the [community] group that was one that [worked]… I think it is because we're only as good as our weakest, the person who's putting the least in aren't we." (F15b).*

Peer pressure also was indicated through the influence of the neighbours. If the neighbours were planting it was indicated that it would motivate the informants to implement further corridor design actions as well:

> *"…if the neighbours get in and start planting and it gets a bit of traction then we'll probably support it." (F14).*

In addition to peer pressure a majority of informants talked of external support as a success factor. Having access to a person, or people who knew how to help or could help was an important aspect. That person-to-person interaction was also a catalyst for further implementation:

> *"Definitely it was a person to person thing. Rather than someone sending a letter and saying you should do this. It was person to person which was pretty important. That's the only way they are going to succeed with these things is the one on one yeah convince them." (F4).*

> *"But having, it was more just the ease of access to the person to do the job, I mean it was a couple of thousand dollars' worth of time his time to come out on-farm look at what I wanted to do, he'd measure it out and go back and draw up a plan and a suggested planting plan and the likes so there was a couple of thousand dollars with that, I mean it's neither here nor there. It was probably just as much the access too [him] at the time and the process." (F2)*

Public opinions were also associated with pressure informants felt which brought to light issues to do with and the informants' rights as the owners of the land. Public interest affected how informants ran their farm and the design and management of their riparian corridors:

> *"…it is a reality that everyone thinks that they should tell me what to do on the property we own. And in terms of environmental stuff that is probably true… But that has been the big*

shift in that ownership rights where, 30 years ago… no one thought they could come and tell you what to do and now you know I'm doing three farm plans a year and I have all sorts of people come walk over the farm and tell me what to do. So the mental shift in that is quite big." (F1).

Although the pressure from outsiders was acknowledged by the informants and the concept of being told what to do often was referenced to negatively:

"Um being told they have to do things is one part of it, farmers are very independent people. Otherwise they wouldn't be farmers. So that's part of it. 'Not telling me what to do'" (F4).

Social factors were regularly cited by informants and come in multiple forms peer, community, industry and regulatory pressure all influenced the informants' riparian corridor design and management. This raises questions about how well the pressure from external groups has been utilised, whether it can be improved upon or if it has reached its full potential.

6.3.3 Access to Information

The majority of informants cited information as a factor that determined their design and management decisions. There were five main sources of information identified: nurseries, advisors, non-governmental organisations (such as Fish and Game) and guides.

Half of the informants identified access to information and their awareness of the issues as an enabler to riparian design and implementation. The overall amount of information from multiple parties was recognised regularly as available and abundant:

"Yeah look there's more information than you can shake a stick at" (F1).

"Aw there's plenty of information out there." (F10).

Most informants indicated they were aware of the impacts of dairy farming on freshwater, particularly with respect to excessive nutrients, but indicated farm-scale monitoring was not available to determine the actual outcomes of their riparian treatments toward reducing these impacts:

"Well yeah I mean stock are excluded, as far as quantifying environmental benefits it's near on impossible isn't it? I mean I know you trust in science and the model and what Lincoln and AgResearch are doing around it, ah so I'm reasonably involved in that nutrient space… So um I'm fairly well aware of the issues at the catchment scale" (F14).

The most common source of information informants used to determine how to design their riparian plantings was a plant nursery:

"I suppose it's nothing to do with um planting natives, more because um because that's probably what the nursery suggested" (F15a).

Informants suggested they trusted nurseries to advise them on the best type of plants to plant in response to their biophysical conditions:

> *"…we are using um [nurseryman] from [name of nursery] who has got a lot of experience so we are using professional advice around plant types and where we plant it and all that sort of stuff." (F1).*

However they said it depended on the nursery, as some informants said they had misgivings about the quality of information they had received:

> *"I think the nursery probably, because it was such a big planting that they probably got rid of a few plants that they had in their stocks you know I wouldn't necessarily do the same planting again if I did it again." (F9)*

Advisors were identified by a minority of informants as being a good source of information regarding the design of their riparian corridors. These included advisors from DairyNZ, their dairy company, and their regional council. While advice was not always utilised, informants said they appreciated it being available if needed:

> *"Um when [the dairy company] came in with their fencing off act or whatever it was called they came round and we talked through it and they pointed out the waterways they could see from the satellite images and stuff. So we talked about it and made up a bit of a plan." (F6).*

However, many informants said they relied on their own experience and knowledge of their land to guide their decision making, particularly with respect to the position of their fencing and type of plants to plant to maximize probability of survival:

> *"Ah a lot of its common sense because you know how stock flow and you know where you want your culverts and your gateways, you know, like the cows always walk to the corner closest to the dairy shed so that is normally where you put your culvert and yeah you fence accordingly" (F5).*

Other informants who had new farms, or were new to that particular area, identified that the local knowledge from other community members was valuable:

> *"…local knowledge the guys that have been here for 50 years are the ones that can give you some guidance around where the river's likely to go and where you might have problems how best to manage it" (F14).*

Information is a very clear influencing factor that is continually changing. How informants are provided information, the best forms of education and the time in which it takes for informants to take on new information, is important. This encourages questions about how to go beyond access to information. How information is *received* could be crucial to improving the influence of this factor.

6.3.4 Ease of Implementation and Management

Many informants indicated they were more likely to implement a riparian corridor design more if it solved a significant farming impact in a logical way which was described as an easy to implement manner at reasonable cost. Fencing for stock exclusion was viewed as logical:

> *"…and we, you know it's just a, the right thing to do in a lot of ways. You know it's just got to be done. You can't not do it." (F15b).*

> *"Do something that makes sense and if it's going to cost me 10,000 dollars to [draws around paddock] to do that, why wouldn't I just spend a couple of thousand dollars in there and get the same outcome" (F2).*

However the ease of management was an issue and the extent of management required was a factor associated to how the riparian corridor was managed. Weeds specifically were identified by half of the informants to be the main reason behind the extent of management required. Willows and blackberry, in particular, were identified by some of the informants as a main cause for major management efforts:

> *"Yeah, just the negatives is just getting it established and the water is weed free and yeah" (F5).*

> *"…controlling the willows and the blackberry you know is no small mission in on itself." (F11a).*

Figure 6.5 shows an example of a planting where the informant had planted a range of natives which are outcompeted by the faster growing weeds, such as blackberry.

Figure 6.5 A photo of a riparian corridor with blackberry taking over the vegetation previously planted. (A. Mark, 2015)

Birds were described as both indicators of success and a factor that prevented it. Some informants indicated having an abundance of birds was indicative of a successful planting:

> *"Actually my cousin said, when she was over here she said that she hears so much more bird life here than she does where she is in [another part of Canterbury]. You know the birds you can hear them" (F11b).*

Others argued birds were detrimental as they brought in seeds of exotic plants that increased management activities:

> *"We seem to be able to grow black berry really well. It's coming, I think it's coming of the hills a wee bit, the birds eat the berries and spread the seed." (F8).*

Although some informants did attest to the increase in work required by management, the positives they had seen after implementation meant they were prepared to continue the management to keep those benefits going:

> *"Oh no just like I say underestimating the maintenance but that's um, the positives out of it will far outweigh the, it's only a minor negative one" (F9).*

Weather events affected success of long-term management of the corridors. For most of the informants the weather affected how the area was managed. For example drought affected the adoption of riparian planting by limiting when it could successfully occur:

> *"We'll just see how they come up like they were supposed to be planted back at Christmas time but it was too dry, the banks [were]. So that got planted in winter." (F12).*

Others talked about weather events such as floods taking out the plants they had implemented. Furthermore, snow inhibited the growth of plants or limited water supply for stock, so stock needed access to the waterways which trampled plants. Dry weather also decreased plant survival:

> *"we did have the drought although this creek didn't go dry over the summer, but yeah there is probably only 10 % of them alive now… and also we get snow here, they had half a metre… and even that sort of, that even knocked big flax bushes down, up there, this last lot of snow last month and it's quite hard on trees and plants." (F5)*

The ease of implementation and management of riparian corridors contributed to how logical an action was to an informant. Implementation such as fencing was seen as an easy and cost effective way to exclude stock. Design that created management such as planting however was not seen to be as logical, as it involved, keeping the plants alive and re-establishing plants that had died, which became factors that affected the success of the corridor. This raises the question of how to make a desirable riparian design and management approach that is easy for farmers to accept and implement. Designs have to be accepted by farmers as necessary, easy to implement and at reasonable cost in both time and money.

6.4 Other Observations

Within the findings there are several interesting points that should be noted. Firstly the findings had no correlation to the size of the farms. The informants who had a herd size of over 3000 had no obviously different opinions to those with much smaller farms.

The setting played a role in influencing the aesthetic values of the informants. For the informants who owned or operated farms in areas other than the plains, such as the foothills, the aesthetic concern was around having a more interesting farm:

> *"that's sort of why I like that farm up there rather than the big pivot and all flat land and you know I like something yeah aesthetically pleasing, not boring" (F5).*

However for informants on the plains the aesthetic value and goal was to look tidy and professional one informant explained:

> *"Like you know our dairy shed… like all the lawns are mown and it sort of get we try to treat it like a food processing plant, we sort of do try to keep it pretty tidy. So it was more the natives around the dairy shed and round the effluent system was more aesthetic than anything yeah." (F9).*

The distribution of those who had fenced and planted compared to those who had only fenced also varied by location. Lowland plains, inland basin and foothill informants appeared more inclined to plant compared to Central Plains farmer informants. This may be due to the type of waterways that are within these landscapes. The Central Plain informants' main form of waterway was stockwater races and irrigation races that are manmade. Informants in the other locations had natural waterways which informants seemed more inclined to plant.

Although all of the informants identified reasons for their riparian design, none of them identified clearly defined measurable objectives for riparian design, or for corridor management. Only one informant indicated that implementation occurred to meet the time frame dictated by the dairy company they supplied to:

> *"Oh yeah, that would be about 10 or 12 years ago, but, yeah, the first lot. And as [the dairy company] has bought that fencing thing out the last of it was done, when did it have to be done by? Last year or something yeah the last of it was done then" (F5).*

This lack of objectives may come from the lack of trust in the policy and regulation that was imposed upon the informants. Most of informants felt that the regulation did not make sense. Informants indicated that they were being given guidance in relation to biodiversity yet were told that the problem was nutrients.

"So, a gully runs through a paddock, fence the bottom of the gully, reduce flows, try have some clean up and concentrate on what's the hotspot or the clean-up point. Rather than planting the whole thing. So that's a debate that sits at our table… hence my question why do you want me to fence the whole paddock and plant the whole paddock if we are talking about nutrient environment outcomes? … I see absolutely no value in planting along there [indicating location on map] for nutrient management. So, if you ask me to plant there, ask me for the right reason which would be biodiversity." (F2).

In addition, they did not think regulators understood how they farmed, or the conditions under which they farmed enough to make informed guidelines:

"…what I am trying to do is the right thing rather than what's regulated. Stuff that makes sense - because the regulation often doesn't, and the people trying to enforce it don't know anything." (F1).

For policy to be trusted it needs to be easily understood and respected by the informants who implement it:

"just suddenly someone puts a rule on you, you know, which doesn't make any sense I mean it makes sense to fence that's just a no brainer but once you start saying well you got to have it, I don't know what the rules are but they're talking about 5 to 20m back" (F13).

It alternatively could be possible that the lack of clear measurable objectives is due to an assumption that their design actions are complete once the design is installed. In other words, the implementation of the design is the goal of farmers rather than to reduce the environmental impacts of their farms on water quality.

Some informants doubted whether riparian corridors would function to significantly reduce their environmental impacts. While informants pointed to technologies that resulted in a noticeable reduction in water use on farms as effective, they did not see the same direct relationship between implementing planting and a noticeable reduction in nutrient leaching. Informants said they would prefer to implement practices that resulted in noticeable improvements, where they received more "bang for your buck". In other words the amount of improvement to ecological processes was important in balancing the relative costs (both financially and in terms of time and labour) against benefits of measures:

"Yup, not that we are perfect but um and guess the reality there is too that there is a lot more than the aesthetics behind you know doing things that are environmentally friendly as well. I guess the foreign buyer probably wants everything looking nice but probably having better irrigation, more efficient irrigation is far more environmentally friendly than having, you know your waterways planted there's probably, its perception isn't it." (F3a).

Informants felt it cost more to implement corridor planting with limited amount of ecological benefit compared to cost and benefits of efficient water use. This attitude can be identified in the catchment level efforts of regulators to set measurable standards for water quality improvements. The extent of the benefit of the action is commonly balanced against the cost to determine the standard set.

Informants were particularly concerned about the lack of attention in advice for managing weeds in their corridors. The obvious option was to spray to eradicate weeds, but the consequence of spraying chemicals near water affected the outcome of improving the waterway's quality:

> *"Well if you read the rules you're not allowed to spray on to water are you. So again all these laws of unintended consequence come into play so the theoretical space is fine but the reality is that every time you make another step you, and so the answer is oh we'll get a good green working party out we've got all these sort of WOFERs that can come out and hand chop and clean up. Oh well that's not the world I live in, and you can pay them to do it I don't actually want to pay any bugger to do it let alone do it." (F2).*

Despite awareness of the downsides of using chemicals, however, only a few informants identified them as a reason not to spray:

> *"Yeah, no, it's the less of two evils, I don't like spraying over water. There's nothing sadder than seeing a sterile creek running down a bare land." (F10).*

6.5 Are Corridor Design Functions Being Managed Through Time?

When the design actions described in section 6.1 are compared to the management experiences of Section 6.2 there is one main inconsistency. The management of corridors by informants is *not* for the benefit of the environment or water quality, both of which are expressed as rationales and priorities for design.

This disconnection could be due to an assumption among informants that the functions of the riparian corridor are achieved through design, without the need for management, that is to say informants believe that management does not achieve any particular function. It is assumed that water quality variables and functions such as filtering functions and erosion control are achieved once the design action is in place. Management is used to meet other concerns. This is shown by how design actions such as aesthetics and stock wellbeing (both of which relate directly to the informants personally) align with management priorities.

This perception is reflected in the lack of evaluation associated with management. The evaluation in management does not occur as it does for design. While informants identified the ways they evaluated their riparian corridor design actions, there was no mention of the evaluation of riparian

corridor management. This could be due to this established assumption that the design is the most important step, and that management does not play a role in the functions a riparian corridor can provide. The absence of evaluation in management could also contribute to the way the riparian corridors are generally managed. This could be due to the way informants evaluate using aesthetic values rather than monitoring a wider range of environmental outcomes.

Aesthetics is a continual theme across almost all aspects of informants' design and management. This suggests that appearance dominates function for informants. Due to the nature of this research, its aim to find insights into farmers' experiences rather than specific aspects of corridor design and management, further research into the aesthetic preferences of farmers and how these preferences effect functions of riparian corridors is needed.

6.6 Conclusion

Informants designed corridors to improve freshwater quality and farm aesthetics. Implementing stock exclusion was a priority, and its design depended on the type of waterway. The riparian design was considered an integral part of the farmer's FEP and considered the placement of the fence to determine width, planting and access to the corridor. Informants indicated they were aware of the environmental outcomes of their designs, and while they wanted monitoring to determine outcomes, were unsure how to get the "hard evidence" to prove outcomes were achieved. To evaluate the success of their designs, most informants performed visual inspections of planting aesthetics as a way of evaluating the success of their designs.

Informants were less concerned about corridor management than they were about its design. They managed for corridor aesthetics, maintenance of waterway flow and control of weeds. While the informants had clear management practices, only half identified the reason for them. The main type of management action was weed management using sprays to eradicate weeds from the corridor. This use of herbicides was favoured for its speed and ease of application.

Overall, the factors that contributed to the success of corridor design and management were focused on four themes; the means to act, social factors, information, and how much sense it made to perform the design component. There were a number of other variables that need to be noted in light of the findings. These are the role location played in action, the lack of clear measurable objectives identified by informants, and a doubt in the ability of corridor design to mitigate larger scale environmental impacts, such as water quality. There was also a lack of consideration of the impact herbicides had on water quality.

When corridor design is compared to management an assumption made by the informants becomes clear. The lack of priority given to water quality variables and the functions of riparian corridors when

managing the corridors suggests that it is believed that functions occur at the point of installation and no management is required to ensure its continuation or maximization. Management is created by design and functions do not need to be managed for. This is also reflected in a lack of evaluation in terms of the management of corridors. Aesthetic appearance is considered by many informants as an indicator of effective function.

The next chapter compares the informants' experiences to the wider policy, best practice and science literature. Additionally it establishes the key implications of this study and the opportunities created for further research.

Chapter 7

Discussion and Conclusion

This chapter discusses whether farmer riparian corridor designs and management are consistent with those promoted in the New Zealand central and local government policy, regulations and guidelines, dairy industry protocols, and science literature. Section 7.1 provides a summary overview of the key findings of this study, and compares them to the current public policy and regulations framework. Section 7.2 identifies how the findings align with the Accord, and section 7.3 compares them with scientific research. Section 7.4 discusses the implication of the results for design, management and policy. Section 7.5 concludes the thesis by summarising the key arguments, notes the limitations of the research, and suggests future research opportunities.

7.1 Comparison of Findings with Public Policy

7.1.1 Overview of key findings

Informants' experience of corridor design and management can be understood under two broad headings - corridor design and management - and in terms of why farmers take action, farmer priorities for and types of action, and how those actions are evaluated by the farmers who undertook them.

Farmer key informants had two main rationales for corridor design: water quality issues and aesthetics. Their main priorities were for stock exclusion and for the values associated with the waterway to be considered in design, while the types of action were based on the distance of the fence to the waterway, and the survival and location of the planting. Famer evaluation of design outcomes was based largely on aesthetic appeal, although "hard evidence" was preferred when available.

Corridor management was considered by only a small proportion of informants. Their rationales and priorities were determined by the flow of the waterway, the risk of contamination by weeds from the riparian corridor to the rest of the farm, and their desire to manage the corridor in such a way to meet their own aesthetic values. The actions used to meet these priorities and rationales were types of management such as weed management, plant maintenance, stream cleaning, and fence maintenance. The effects and success of these management actions were not evaluated.

7.1.2 Design

Growing concerns for water quality in waterways and lakes across New Zealand prompted the National Policy Statement for Freshwater Management (2014) (prepared under the RMA), which suggests riparian corridor design as a way to remedy issues, in conjunction with other water management tools (Ministry for the Environment, 2014a). This focus of public policy aligns for the most part with the rationale and priorities of informants in regards to riparian corridors. Priorities of the NPSFM include stock exclusion from lakes and waterways, and protection of waterway values (Environment Canterbury, 2015b; Ministry for the Environment, 2014a) which also aligns with the informants' views. This suggests that farmers are aware of and respond to wider public policy concerns.

The most prominent *difference* between informants' responses and public policy in regards to waterways relates to goals for human health, which are given more significance in public policy than in the informants' rationale. This could reflect the different drivers of public policy and farmers. Public policy is a reflection of broad political and social issues, while farmer actions are a reflection of their farm based worldviews and complex circumstances as land owners, producers, and citizens (Duncan, 2014; Primdahl et al., 2013). Farmer informants focused on the importance of their land presenting an image of care, showing the public that they were doing a good job and run their farm well (Nassauer, 2011), rather than providing specific public benefits. This inconsistency highlights a broader tension within the RMA, which intended to address the effects of private use of land and management on the wider public good by having 'the polluter pay' for costs of mitigation.

In terms of types of action, public policy does not provide recommended dimensions for riparian buffers, which is understandable based on the diversity of landscape situations, and the recognition that scientifically "one size does not fit all". Renouf and Harding (2015) for example suggest that the current dimensions of Canterbury's riparian corridors are insufficient to achieve many corridor functions. The lack of policy guidance or consensus when it comes to corridor width means that farmers are left to figure it out themselves and make judgments based on the information they have been given. The inconsistent information may also lead them to believe that until further evidence is provided stock exclusion is all that matters, thus a narrow width is all that is necessary.

The findings of this study suggest that it is the pressure from both public policy and industry that has encouraged riparian corridor design in Canterbury. This influence is consistent with the literature (Bewsell et al., 2007; Cullen et al., 2006; Monaghan, Carey, et al., 2009). However farmer informants displayed mistrust towards regulators and the outcomes that will be achieved by implementing policy guidelines and regulations, and responded negatively to being told what to do. Some informants indicated that they were being told that the problem was nutrients but the guidance was

being given in relation to biodiversity. Others believed that the people making the policies did not understand farming. This suggests that the mistrust could come from the multiple and at times conflicting goals identified by policies (Mitchell, 1997).

The findings indicated that the action of riparian corridor design is becoming an approach accepted within the informants' culture, as a way to improve ecological functions and to be a "good farmer". The data shows that riparian design for stock exclusion has become commonplace as it "makes sense" to do it. This influences implementation and motivates farmers to undertake corridor design. The informants clearly indicated that the idea of corridor design is accepted as best practice. However further research is needed to determine the way in which farmers decide what makes 'common sense'. The findings of this study suggest that it may be the ease of a practice that contributes to the 'common sense' indicated by informants. Yet, this does not interrogate the factors that contribute to practice being 'easy' to implement. To some extent, from the data reported here, it would appear to involve the extent to which it conforms to existing understandings of good or appropriate practice in NZ dairy farming.

Evaluation of the effectiveness of wider water management actions, on a catchment scale, specifically in areas regularly used for swimming, is the responsibility of regional government (Environment Canterbury, 2015b). Monitoring results are provided publically. However allowing for better distribution of data particularly to those farmers along the tributaries sampled could improve the evaluations the informants are making about their corridor actions.

7.1.3 Management

Informant rationales and priorities for riparian corridor management actions align well with wider public policy. However the way weeds are managed and how plants should be maintained have become issues of conflict. Stream cleaning is indicated as a necessity in Canterbury's bylaws and a number of drains are routinely maintained by Environment Canterbury, requiring landowners to allow for the reach of digger arm into the waterway. However the latest information from Environment Canterbury (2015a) suggests the use of waterweeds as a passive way of nutrient uptake, habitat creation, and instream shade. Farmer informants instead wanted to maintain flow to reduce the flooding of paddocks by relieving waterways of blockages. The use of waterweeds was not mentioned by the farmers in this study. This could be due to the recent nature of the information, the time it takes to be disseminated and how long it takes for farmers to begin to implement new tools. As identified previously, information is an evolving factor in corridor design and management and should be addressed in a way that reflects its nature. The constant re-evaluation and progression of policy actions for corridor design requires education and new information to continually reach farmers.

When informants' responses regarding vegetation in corridor management are compared to the wider public policy goals and recommendations there is a lack of recognition of the link between vegetation management and long-term functional outcomes for waterways and freshwater quality, which could have allowed farmers to take a narrower approach that is possibly misguided. Nurseries were the main source of information to the informants who had planted which reflects the finding noted that information is not constant, but emerging factor in corridor design and management. Therefore further research and understanding of what guidance and assistance nurseries provide could benefit wider public policy goals, and ensure that the farmers are implementing the right plants in the right places to ensure that corridor functions are met.

A minority of informants spoke of Farm Environment Plans (FEPs) and the use of them in planning riparian corridors and the setting of goals for further riparian implementation. However wider use of FEPs to provide for corridor management that delivers riparian functions would help to address management issues. Guidance that provides clear definitive information that addresses the specific issues within each Canterbury area, and which considers pragmatics surrounding the nature of the types of waterways and values associated could be a useful inclusion in FEPs.

7.2 Comparison of Findings with Accord Practice

The Accord is an agreement between dairy companies, DairyNZ and government. It is currently the most influential sector agreement to affect the dairy farmer, and comprises industry "best practice" informing corridor design. The government effectively has given it their "blessing" showing that the intent of the Accord aligns with their overall goals. It is not surprising therefore that the relationship between key informants' responses and the Accord priorities and actions are reasonably similar to those for wider public policy identified above in section 7.1.

7.2.1 Design

This section compares key findings from informants with best practice as set out in the Accord. The views expressed by the informants align well with the Accord rationale. The focus of the Accord is upon water quality issues and as noted this supports the reason for informants' implementation of corridors. The Accord is a way that dairy companies "encourage" farmers to implement corridor design, championed by the government as a voluntary, collaborative approach that avoids the necessity of it to become a part of the regulatory process (Fisher & Russell, 2011). This reflected in the informants' rationale for action, who noted that corridor design can be a way to avoid or manage the risk of being regulated more harshly by regional councils.

The Accord suggests that vegetation be used "where it contributes to water quality" while failing to give specific instructions for meeting this, other than a requirement for a riparian management plan which is to be completed or implemented by 2030 (DELG, 2013). The informants follow this lead by indicating that planting is "targeted" in corridor design. However the effectiveness of this targeting and the information used could be questioned. The recent DairyNZ guide offers information that specifies the plants that should be used to provide a certain function. For example, a swamp sedge (*carex virgate*), stabilises slopes, filters runoff and benefits fish habitats (DairyNZ, 2014). It seems that this information provides the material that is needed to align the informants' corridor design with functions for improved water quality and aquatic habitat. It raises the question of whether farmers are actually using this guide to determine the type of design actions taken. However, DairyNZ guides have only recently been developed and available to farmers. Further research will be required to determine the extent to which farmers are following these guidelines, which is a requirement of the Accord (2013).

While the importance of access to and awareness of information was expressed by farmer informants, it was also identified by the informants that there was more than enough information and education provided. Informants favoured information offered by nurseries, person-to-person advice and their own understanding developed through experience to effectively implement the different aspects of corridor design. This suggests that while informants were aware of information provided by industry, the way in which they accessed it and the value they saw in different forms is an important influence on corridor design.

The Accord is reliant on farmer records of implementation for evaluation. It specifically notes that the length of stock exclusion and implementation of riparian vegetation should be recorded by the dairy companies on an annual and biennial basis (DELG, 2013). However it is not specified if monitoring will occur to gauge the effectiveness of Accord (2013) practices on the environmental outcomes of concern. The findings show a need for monitoring to motivate farmer management and design. The Accord should provide for this or require more specific recording of the effect of implementation. The Accord has the opportunity to require monitoring to be done by dairy companies alongside the recording of the extent of implementation, which would provide a more comprehensive evaluation of the Accord's success. This evaluation should also be set against targets outlined for the catchment by the Regional Plan which is intended to be established to meet the desires of the public.

7.2.2 Management

Although the Accord links corridor design to a wide range of environmental functions with a focus on issues of stock and water quality, there is no consideration of management post implementation.

However guidance associated with the Accord such as information provided by DairyNZ does align with the rationales expressed by informants. Additionally Farm Environment Plans could provide an opportunity to deal with the lack of management objectives provided for in the Accord itself.

The lack of emphasis upon management within the Accord is reflected in the small proportion of informants with rationales and priorities for management. The Accord and informants both perpetuate the assumption that design is the important step, function does not require management, and it is the farmer's design that creates management problems such as weeds and untidiness. As the Accord focus is stock exclusion first and foremost it seems likely that management is over looked. However the Accord does require vegetation where water quality improvements can be made. Therefore functions provided by management of vegetation should be included in the Accords corridor requirements.

FEPs could be part of the solution, but the use of FEP to achieve management could be improved. Setting and providing monitoring to ensure function aspects are achieved and to establish management that continues to deliver functions could be a component of a FEP. Providing and improving upon the management approaches used by farmers in this way could give them an understanding and awareness of the need for management to prioritise functions as well as aesthetics, flow and weed containment management.

7.3 Comparison of Findings with Literature

7.3.1 Design

This section compares the views of informants to the previous literature and scientific evidence. Overall, the findings concerning farmer experiences and actions align well with the evidence provided in literature in relation to water quality and aesthetic rationales associated with riparian corridors. However there were inconsistencies in terms of the rationale for recreation and aquatic habitat and in the decisions made around riparian margin width. Finally a comparison is made between aesthetic evaluations and the use of 'citizen science' for improvements in monitoring.

As described in Chapter 2 there is extensive scientific evidence that riparian corridors offer functions that improve and maintain water quality, aquatic habitats and aesthetic, recreation and amenity values (Berges, 2009; Burrell et al., 2014; Collins et al., 2013; Kerr & Swaffield, 2012; Marchand, 2006; Parkyn et al., 2000; Wilcock et al., 2006). The findings of this study suggest that the rationale and priorities for riparian corridor design expressed by farmer informants in Canterbury New Zealand are broadly consistent with the scientific evidence on corridor functions. In particular the literature indicates that water quality in freshwater streams in production landscapes is in decline both in Canterbury and New Zealand (Parliamentary Commissioner for the Environment, 2015b), and the

informants' responses indicate that they accept this reality and give it as the reason for their corridor design and implementation. They particularly highlight the importance of stock exclusion and planting to reduce nutrient inputs to waterways and reduce bank erosion, and hence improve water quality.

Alongside these concerns for water quality, the study findings suggest that aesthetics are an important influence on how farmer informants approach and evaluate corridor design. This is also consistent with the literature. Kerr and Swaffield (2012) for example identified vegetated and well-managed areas alongside streams as an important indicator of stream amenity in Canterbury, which aligns with the reasons given by informants for their corridor design. Nassauer (2011) also identified importance of appearance of farmland in the United States in showing the land is being cared for, which she refers to as "cues for care," and indicates the proficiency of the farmer (see also Fairweather & Keating, 1994). This sensitivity to how others will look at their farming is found in the informants' comments and in their priorities for design and implementation of planting along waterways on public roadsides before other parts of the farm.

However in contrast to Kerr and Swaffield (2012) the Canterbury based farmer informants gave little recognition to the recreation and habitat values that a riparian corridor can offer. The rationale and priorities used by informants to justify riparian corridor design largely ignored habitat and ecological functions. This could be due to the relationship farmers have with their waterways in intensive production areas, which for the most part are not used for public recreation, or recognised as having particular habitat values. This suggests that the priorities for action may come down to the values the informants associate with the type of waterway involved, and its location. This in turn has implications for how farmers might be encouraged to enhance waterway values within their farms (see section 7.4).

The range of factors identified in scientific evidence as influencing the width of the riparian corridor is unresolved (Hansen et al., 2015), and this may be the cause of the inconsistency between the scientific literature and the informants' responses. Width in the literature is determined by the functional requirements of improving water quality, and a variety of sources indicate that there continues to be a general consensus that a width of 10 metres and over (Parkyn et al., 2000) is the most effective to achieving most functions. However the width recommendations vary based on the slope of the land, the soil type and the waterway type as well as the vegetation, the function and the level of performance aimed for (Parkyn et al., 2000; Hansen et al., 2015). Collins et al. (2013) indicate that water quality variables can be enhanced to some degree no matter the corridor width. However the findings in this study show that the Canterbury dairy farmer informants were designing with a range of other farm-based variables in mind, such as having a straight fence, and the ease of

maintaining the land, rather than environmental functions. This led to the designed width of riparian corridors on these farms being at times significantly less than 5 metres. The implication of this is that the considerations used by farmers to guide their actions are shaped by existing farming practices. This in turn raises the question about whether there is potential for policy and public opinion to change the assessment framework that farmers apply to riparian design, and how this change occurs.

However, while there may be a lack of consensus, there is no lack of science on the effectiveness of buffer widths. Width is dependent not only on the farming system but also on the specific biophysical conditions, and requires multi-scaled monitoring of the catchment to determine the effectiveness of designs. This becomes difficult when it is uncertain as to who does the monitoring. Farmers may be unable or uninterested in doing the monitoring themselves, therefore the question becomes whose job is it to protect the public interest in water quality? The management of the environment often falls to the land managers, while monitoring and reporting of environmental management effectiveness is a responsibility of regional and central government (Valentine et al., 2007). Regional councils ideally work in the interest of the public and therefore improved government leadership is required to set riparian margin standards for different types of waterways and regions in response to regional monitoring. However it is acknowledged that, while this is an important responsibility of councils, the costs of monitoring are not usually within the budgets of these entities

The literature identifies the use of specific species of plants used to address different functions. Farmer informants used targeted planting of areas that they deemed to be the most effective in producing the water quality functions they were prioritising, and designed for the survival of these plants. This approach is consistent with literature which suggests vegetation be targeted to areas where it best serves the desired function (Parkyn et al., 2000; Quinn, 2003). However the literature is not specific to the species of vegetation which is most likely to survive in a given region.

Informants *evaluated* their riparian design actions predominantly through an aesthetic evaluation. If it looked good their action was successful, whereas if it looked bad then they had failed. This use of aesthetics as an evaluation of success has been identified in previous research which identifies how aesthetics relates to ecology. People appear to value ecosystems that are perceived as healthy, but many do not recognize ecological health when they see it (Gobster et al., 2007; Swaffield & McWilliam, 2013). Gobster et al. (2007) suggests that what “looks good” in agricultural landscapes (a well-cared-for and tidy riparian corridor, for example) may actually be ecologically damaging. It is not known whether a positive farmer aesthetic experience of their riparian corridor reflects effective provision of functions such as water filtration. However, aesthetics are important to farmers and need to be considered when policies are being developed to guide and encourage farmer implementation of effective corridors. Further research on farmers aesthetic experiences of riparian

corridors, and how they affect and relate to riparian functions and water quality, is required to guide policy in order to encourage new aesthetic norms among farmers in support of healthy riparian corridors (Gobster et al., 2007).

Science relies on monitoring for evaluation, and farmer informants expressed a desire to have access to concrete, scientific evidence which showed their design to be a success. The informant interviews suggest that only a small number were actually provided with monitoring data. When monitoring had occurred the information was used, suggesting that further research into ways of allowing farmers to be involved in the monitoring of water quality could be productive in improving implementation and management. 'Citizen science' has been investigated in terms of an urban community's ability to monitor stream water quality (Stewart, 2001), in which simple monitoring programmes completed by communities provides for sustained and effective management of freshwater. There is an opportunity for using citizen science techniques in regards to riparian corridors.

Alternatively further monitoring by outside parties and provision of data to farmers could be useful. The requirements of regional authorities to monitor the ecology of the region could provide general knowledge of the state of the ecosystems in the area. As expressed previously there is a role for regulators who are responsible for the protection of public interest in water quality. The knowledge of regulators needs to be provided for farmers to receive the desired "hard evidence" for improved riparian designs and implementation and ultimately management.

7.3.2 Management

This section describes how the findings from key informants compare to the management practices identified in scientific evidence. Overall informants saw little value in management for riparian function to be maintained, rather, their management was based on the effect the corridor now had on their farm, the labour and time.

Hale et al. (2011) suggest there is a lack of long-term management because of the misconception of short timeframes associated with ecosystem recovery, and argue ongoing management long-term is necessary for functions to be realised. This was not expressed by the informants. Only half of the informants gave priorities for management action, and even these rationales and priorities failed to focus on the need for management for riparian functions to be maintained. This suggests that there is an assumption among the informants that the management of riparian corridor functions are achieved through corridor design installation, whereas management is about the effect the riparian corridor now has on their farm and farming. This raises the question of whether farmers are aware of the connection between long-term management and the provision of functions and additionally what is required of management to deliver corridor functions. It also points to a shortcoming in the

approach incorporated within the accord which treats mitigations of water quality as one of initial project implementation as opposed to a continuing farm management and maintenance practice (a shortcoming discussed further below).

There is possibly a missing connection between the science, the time and cost associated with management and the practical issues faced by farmers. Management therefore needs to be effective in achieving function and be cost efficient for farmers to improve their management techniques. For example, while science has identified the problems of certain chemical use near water and the disturbance to habitats due to mechanical clearance of in stream vegetation (Misra et al., 1996; Sinton, 2008), there is less focus on investigating ways to retain ease of certain weed removal techniques without the adverse environmental consequences. This raises the question of whether the solution is better education in the consequences of management, ways to manage to continuously deliver functions, and new techniques for weed management that might better solve these problems.

While design actions have been studied in terms of the means required for implementation (Rhodes et al., 2002) management actions have received less attention. Rhodes et al. (2002) suggests financial motives influence design, however this does not indicate how it affects the management of the corridors after implementation. In this study financial means was identified by the farmer informants as an important factor, with the cost of management cited as a barrier. Means is not only a problem in terms of decreased farm production (as shown by Parminter, 2008), it was also cited in relation to the practicalities of accounting for weather events and having the time to manage riparian corridors. The data in this study indicates that there is a mixed response to funding, while some informants identified it as an enabler, others felt there was too much administrative effort required for the benefit received.

7.4 Implications

The comparison of the findings with scientific evidence, practice and wider policy has a range of policy and research implications. The separation of corridor design from corridor management in the analysis has allowed assumptions to be revealed, and in turn identifies a need for further research and recommendations for improved design and management of riparian corridors. In essence the core issue raised is that there is a focus on *outputs* by all parties involved, for example the implementation of fencing and planting resulting in a riparian corridor, rather than a focus on the *outcomes* of the implementation, for example the effectiveness of the corridor providing a range of functions over time.

7.4.1 Implications for Industry Practice and Public Policy

This research gave insight into the experiences farmers had in implementing the industry practices for riparian corridors that are outlined in the Accord. There are a range of implications for both practice and wider public policy.

The need for continuing management and maintenance to ensure riparian functions receives very little attention in either industry practice guidelines or wider public policy. The findings suggest this is also true in the informants' own management. Further research is needed to determine ways in which public policy and practice guidelines such as the Accord can ensure that farmers are managing their riparian corridors on a continuing basis to provide the functions needed to ensure water quality and ecological habitats. Allen et al. (2002) suggest the success of policy objectives depends on the co-operation of different societal groups and a shared understanding to be fostered between them. For corridor design and management to be completed in such a way that long-term outcomes are achieved, a framework that provides for it needs to be implemented (Allen et al., 2002). Empowerment of people is key, therefore if an understanding of farmers worldviews are not considered it is likely to limit the success of policy outcomes (Duncan, 2014).

The way the Accord evaluates its own success could provide an opportunity for this. If in addition to the linear extent of stock exclusion, the Accord also asked for monitoring of effectiveness of stock exclusion in improving water quality, it would provide farmers with the scientific information they want and encourage a management culture of continual review and improvement. It would also give a more accurate portrayal of the Accord's long-term success. A way of integrating this into the current actions farmers are taking could be to make Farm Environment Plans extend beyond corridor design to include a strategy for monitoring of instream conditions and values. This approach could also help to shift farmers' aesthetic values by giving them an understanding of what management is needed to improve water quality. As FEPs have recently become a requirement for dairy farmers under the Canterbury Land and Water Regional Plan (2015), there is also the opportunity for this approach to be part of wider policy.

7.4.2 Implications for Science

Four notable implications for science have arisen in this discussion. Firstly, there is a need for further research into the ability of the current riparian corridor design actions of farmers to provide habitat functions. The findings suggest the informants assume that small rural waterways have less of a role in aquatic habitat functions, and this needs to be critically examined. Secondly, improved understanding of aesthetic values that support the functions for improved water quality and habitat functions could be helpful in improving informants' corridor design and evaluation of corridor design

success. A third implication is the need for monitoring to give farmers feedback on the functions that the riparian corridors are providing. This could be done through programmes which provide farmers with the ability to personally monitor their waterways, though this could be questioned due to the added time and effort. Alternatively, monitoring could be provided from outside sources.

There is also an assumption among the informants that design actions result in corridor function. Management techniques and actions used by informants are not for water quality but for farm-based aspects such as weed management and aesthetics. These are a consequence of design rather than an integral part of the overall long-term design-and -management of the riparian corridor. This suggests a need for research into education processes to inform farmers of the requirements of management and how to manage for function as well as their own priorities such as flow maintenance, weed containment and aesthetics.

Information is an essential factor to promote a change in behaviour and provide the support of sound decision-making. However it is also important to note that to only consider information in regards to its transfer, for example guidelines, fails to acknowledge the system as a whole. (Allen et al., 2002) suggest that if the behaviour of a group of people is hoped to be altered (in this case the continued management of riparian corridors), then linear transfers of information and education such as workshops are unlikely to succeed in promoting change. Duncan (2014) argues that "out-of-sync problem framing" should not be dismissed as a lack of understanding of science or recognition of effects on water quality by farmers. This interpretation fails to consider farmers' perspectives of reality which are important to the implementation of corridor design and essentially expectation for long-term management. Long-term management of corridors needs information and education to go beyond policy aims and guidelines to consider the perspective of the individuals implementing, designing and managing the corridor. The focus needs to be on the outcomes rather than the output.

7.5 Summary and Conclusion

According to the PCE (2015), the intensification of dairy farming in New Zealand is one of the main factors leading to the cumulative degradation of water quality in surface waterways. Rural waterways have become subject to increased nutrients, pathogens, sediment, temperatures and a loss of aquatic habitats. This is caused by stock in water, loss of streamside vegetation and runoff from adjacent land. Riparian corridors provide for functions such as filtering of runoff, uptake of nutrients, offer shade and control of erosion that can address these problems, and the dairy industry and wider public policy have implemented programmes that use voluntary approaches to encourage farmers to implement stock exclusion and riparian planting. In an increasing number of regions this voluntary approach is becoming underpinned by rules under the RMA.

This study examined farmers' design and management of riparian corridors by seeking in-depth understanding of farmers' experiences, which has revealed insights into what is being done in terms of management of riparian areas, the implications for science, best practice and wider policy. A feature of this investigation has been the way it has differentiated between farmers' experiences and actions in relation to corridor design, and corridor management, which has been vital to identifying and understanding key assumptions made by informants.

The method used to gather this information was an inductive, qualitative, case study which examined riparian corridor practices and experiences of a key informant sample of Canterbury dairy farmers. The data was gathered using semi-structured in-depth interviews, which were favoured because of the richness in evidence that they could provide. These interviews were transcribed and analysed for themes.

The key findings show that farmer experiences of corridor design and management can be broken into four categories: the rationale for corridor actions, the priorities of actions, the type of action and an evaluation of the actions.

For corridor design, the main reasons for action were water quality issues and aesthetics and the main priorities were to exclude stock, and the values that were associated with the waterway itself. The corridor design actions were based on fencing at varied distances from the waterway, the survival and targeting of planting, and providing access to the corridor and waterway. Evaluation was mostly done by judging the corridor by its aesthetic values, although the informants would prefer to have scientific information provided from monitoring.

For actions relating to corridor management the rationale and priorities were based on three themes, to maintain flow of the waterway, to contain the spread of weeds, and to make it look good. The type of action was based on weed management, plant maintenance, and stream cleaning and fence maintenance. While the informants' experiences in design of riparian corridors contributed to all four of the categories, in management they had they had limited means to evaluate the water quality benefits of management. Additionally there were factors which influenced both design and management actions, which included access to means, social aspects, information and the 'common sense' of the action.

When comparing design actions to management actions, it became apparent that the informants were designing for the functions that riparian corridors provide to improve water quality. However the management of corridors was based on reducing the impact the corridor has on the informants' land management. For example the removal of weeds was to reduce spread on to the rest of the farm; the maintenance of waterway flow was to keep the surrounding land from flooding. This

suggests an assumption that the design provides the functions, while corridor management is the response to design rather than part of it. Hence management of riparian corridors is not connected to managing for the functions that riparian corridors are intended to provide. There is also an apparent dominance of appearance over function, as farmer actions for both design and management express a common evaluation approach that is grounded in the aesthetic values associated with riparian corridors.

However as noted in the Chapter 5 a limitation of this thesis is that while the findings give an insight into farmers' experiences in corridor design and management, it is also important to acknowledge that farmers who were already engaged and responding positively to riparian design and management may have been more likely to agree to take part in the research. This means that the attitudes and actions of dairy farmers who have limited or no implementation or have negative experiences with corridor design and management may not be addressed in the conclusions of this thesis. However the knowledge gained from this study has useful implications for those who have implemented corridor designs and identifies a number of gaps that need to be addressed in corridor management.

The findings have been compared to the science literature, industry practice in relation to the Accord and wider public policy. The evidence suggests that for the most part the informants' design was in line with the relevant scientific literature. However with literature there is variable information about the effectiveness of buffer width and this lack of clarity could relate to the narrow buffers used by the informants. The management actions identified also differ due to the assumption that the implementation of a design will achieve the desired function without specific management. In terms of comparisons with the Accord and wider public policy, the informants seem to be responding to the goals and approaches used, but they were also moving beyond the rationales and priorities of the Accord. It appears that the lack of consideration of post implementation management and maintenance in policy and advice contributes to the continuing functions of riparian corridors becoming neglected in the management regimes implemented by farmers. Essentially the key finding is that there is a focus on short-term outputs and limited capacity to consider the long-term required management.

There are two clear implications of this research. Firstly there is a need to improve management to meet the functions for water quality, through education. Education could extend past the advisor or guide to working with nurseries to provide information and management that ensures functions are provided by these corridors. Secondly the Accord could extend requirements for monitoring to be more than just the extent of stock exclusion, to consider the effectiveness of corridor actions on a wider range of environmental functions- for example using an ecosystem services framework. This

monitoring could be provided as part of the Farm Environment Plans, which would mean that farmers are provided with the information needed to improve their evaluations of corridor design and management, in turn shifting the focus to outcomes rather than outputs.

This research raises several questions. Further research is needed on the aesthetic values of farmers and the effectiveness of aesthetic evaluations to meet the requirements for riparian functions. Supplementary knowledge could come from a larger scale more quantitative survey. Further scientific evidence could also address the gaps established in this study by identifying the effectiveness of farmers' management practices.

Overall this research contributes to the current body of knowledge by establishing the consistencies and inconsistences in design and management of riparian corridors for dairy farmers, furthering understanding of management approaches in Canterbury and providing insights into the effectiveness of policy approaches within the dairy sector. This study identifies a gap in understanding and practice between the design of a riparian corridor and its subsequent management.

Appendix A

Interview Guide

Name(s):

Role:

Opening- Establishing farming situation

1. How long have you been dairy farming?

    a. How long have owned this farm?
    b. Was it a family farm?
    c. What were you doing before farming
    d. How did you come to buy it?
    e. How big is your farm?
    f. How many cows you milking *(seasonal supply milking or year round once a day twice a day)*
    g. Do you have employees *(how many, time)*

Management of the riparian areas

2. **How many waterways do you have on your farm?**

(Accord specific, how many fenced, how long are they? how do you define what a waterway is?)

3. **What sort of riparian management have you got in place?**
*(fencing/ type of fence, planting? When did you start to establish it? Would you like to do some planting? Size, why that size. Reasons **WHY** for putting it there)*

4. **What were you trying to achieve when you put the [fencing/planting] in?**
(Have those things been achieved. How do you determine that you have achieved them? Goals and objectives, where do you think you're going from here?)

5. **Now that you have put the [fence, planting] there how do you manage it?**
(*What is happening behind the fence? - Grass? Weeds? Planting? Why is that happening? Access to the area get stock out. If planting: What type of plants and why them?)*

6. **Why do you manage it that way?**

(benefits, goals and objectives)

7. **Is it working out for you?**

(Is there anything preventing you from managing it another way? Do you see any positives/ negatives to managing it? Has the stock exclusion helped with your farm management (rotations, more fencing ,better subdivisions, stock management)

8. **What information did you use in deciding how to manage/ implement it?**

(*Information/guidelines/ help did they have in implementing/managing it, do you see it needing management in the future)*

Enablers

9. **Do you think you had enough help in designing/manage your riparian area initially and now?**
   (Access to information; commitment; means sufficient money, knowledge, time, how much does it cost to maintain a riparian area? If planting has costs changed overtime?)

10. **Do you receive any outside help to manage the area?**
    (Tax deductions, free fencing/plants or labour (means))

11. **If you had received any of these, would it/did it motivate you to do something different in your waterway or manage it differently?**
    (Means; commitment)

Other

12. **What do you think regional councils are trying to achieve by creating policies that enforce stock exclusion?**
    (Goals/objectives; commitment; means (supporting regulation))

13. **Why do you think dairy companies encourage fencing/planting?**
    (Access to information; means; understanding of cause and effect relationships)

14. **Do you think what you are doing with your riparian areas affects water quality?**

    (Biodiversity, Carbon sequestration, Aesthetics, Appearance of health,) What about if it were done on a catchment basis? (Tractability)

Closing

15. **What would you do differently if you were to do it again? If anything?**

16. **Is there any advice you would give to someone else intending to do the same as you?**

17. **Do you know of anyone else who I could talk to and might have something to share about this topic?**

Appendix B

Initial letter

23rd June 2015

Participants Address
17 Sir Gil Simpson Drive
Christchurch

Dear [Participants Name],

My name is Abi Mark and I am studying a Master of Water Resource Management at Lincoln University. To complete my degree I am doing a research project that investigates the experience farmers have after they have implemented stock exclusion fencing from their waterways.

I come from a farming background and I think that issues that farmers face in regards to water and waterway management need to be understood for better management.

You have previously participated in a stock exclusion survey for Fonterra in 2011. I have used the participant information from AsureQuality to make contact, but my research is an entirely independent project, I am not affiliated with AsureQuality in anyway and your participation is completely voluntary.This study aims to look at how managing your riparian areas are going. Would you be interested and willing to be involved in an interview with me? It would be of great help, so that I can gain an understanding the practical experience of implementing riparian fencing?

Participation is completely voluntary. I will give you a call in a week to discuss my topic further and see if you are interested in getting an information sheet.

If you have any questions now feel free to send me an email or give me a call.

Kind Regards,

Abi Mark

Appendix C

Example Research Information Sheet

Lincoln University
Faculty of Environment Society and Design,
Waterways Centre

Research Information Sheet

You are invited to participate in a project entitled:

Dairy Farmers' Management of Fenced Riparian Areas: A Canterbury, New Zealand Case Study

Please note that participation in this project is voluntary. This project is hoping to gain an insight into your experience of managing fenced riparian areas, after they have been implemented.

This project is a Master's thesis. The aim of this project is to gain knowledge and understanding of the issues and experience of dairy farmers who have implemented fencing of riparian areas on their farms. There is limited published knowledge surrounding the long-term aspects of managing riparian areas from a farmer's perspective. This research intends to address this. Ultimately the benefits of this knowledge will be in the provision of new information for farmers, industry and policy makers in their encouragement of management of riparian areas, and indicate possible future issues for recent policy and voluntary approaches.

Your participation in this project will involve a face to face interview that will take approximately 45min to 1.5 hours and will be arranged to be anywhere that suits you, if you would like to show me an on-farm example it would also be appreciated. I will be accompanied on my field visits by an assistant who commits to maintaining confidentiality regarding all facets of the study.

Assistant Name: Peter Copsey

Signed:  Date: 24/06/15

Questions will be open ended and ask about the riparian areas on your farm and the experiences that you have had with fencing and managing them. With your consent interviews will be recorded, you may elect to be interviewed without audio recording (i.e. notes only). They will then be transcribed.

Once the transcription has taken place, which is likely to be by August 2015, you will be offered the opportunity to review the interview transcript and check for accuracy before it is analysed. You may withdraw from the project, including withdrawal of any information you have provided, up to the time at which you agree that the transcribed record is an accurate and fair account of the discussion.

The summary results of the project, including some direct quotes, will be used in the final thesis submission and may also be presented to interested bodies, and /or published in other forms, but you may be assured of your anonymity in this investigation. Specifically, the identity of any

participant will not be made public, or made known to any person other than the researcher, her assistant, supervisors and the Human Ethics Committee.

To ensure anonymity the following steps will be taken:

- Transcripts and data will be labelled using pseudonym codes
- A separate and secure list linking the pseudonyms codes to the names of participants will be maintained.
- When data is reported, only summative analysed data and anonymous quotes will be presented so that it cannot be linked back to individual participants, to maintain your anonymity.

The project is being carried out by:

Abi Mark
Email: abi.mark@lincolnuni.ac.nz
Phone: 022 032 0595
She will be pleased to discuss any concerns you have about participation in the project.

Supervisors:
Simon Swaffield
Email: simon.swaffield@lincoln.ac.nz
Phone: 4230476

Wendy McWilliam
Email: wendy.mcwilliam@lincoln.ac.nz
Phone: 4230477

The project has been reviewed and approved by the Lincoln University Human Ethics Committee

Appendix D

Example Participant Consent Form

Dairy Farmers' Management of Fenced Riparian Areas:

A Canterbury, New Zealand Case Study

I have read and understood the description of the above-named project. On this basis I agree to participate as a subject in the project, and I consent to publication of the results of the project with the understanding that my anonymity will be preserved. I understand that I may withdraw from the project, including withdrawal of any information I have provided, at any point up to the time at which I have agree that the transcribed record is an accurate and fair account of our discussion.

Name:

I give permission to be audio recorded: Yes ☐ No ☐

Signed: _____ Date:

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