Evaluation of an agri-environmental program for restoring woody green infrastructure within pastoral dairy landscapes: A New Zealand case study

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Pastoral landscape woody vegetation provides ecosystem services, but potentially competes for space, light and nutrients that could provide additional farm production. A questionnaire determined the values and behaviours of New Zealand dairy farmers to evaluate voluntary agri-environmental programs for restoring woody vegetation. Findings indicate the area is increasing, while the composition and configuration of networks are changing and redistributing. Farms with little are losing more, and those with more are gaining. Farmers are planting new areas to increase their public ecosystem services, but may not provide these services through planting and management. Barriers include insufficient private woody vegetation ecosystem services, and low rates of growth of native plants. Government incentive programs are ineffective in overcoming barriers. Farmers may be motivated by stronger evidence of valued ecosystem services, information about their benefits and drawbacks, and how to support services through planting and management. However, a targeted environmental stewardship scheme is required to overcome barriers to planting, with government and the dairy industry working together to develop and maintain a landscape-scaled woody vegetation network on private and public land. Such networks would build sustainability and resilience into dairy farming, leading to an equitably sharing of benefits and costs of their public ecosystem services.

Key words: Multifunctional agriculture; Ecosystem services; Woody vegetation green infrastructure; Intensive pastoral dairy farming; Voluntary agri-environmental programs

1. Introduction

Woody vegetation within rangeland dairy landscapes provide many public and private ecosystem services. They mitigate extreme weather that reduce grazing, milk production, and cattle wellbeing (NAWAC, 2014); provide beneficial insect habitat reducing pasture pests, and pollinate adjacent croplands (Jonsson et al., 2008); improve pasture growth where conditions are dry and windy (Hennessy et al., 2007); provide supplemental income through lumber production (Hawke and Tombleson, 1993); and sequester carbon (Czerepowicz et al., 2012). They also mitigate negative effects of agriculture such as soil degradation and desertification; assist in filtering sediment, nutrients and fecal contaminants from pasture runoff, and improve water clarity and channel stability within waterways (Parkyn et al., 2003). Furthermore, they significantly contribute to aesthetic experiences of farms and the landscape (Swaffield and McWilliam, 2013), signaling environmentally healthy dairy farming practices (Hughey et al., 2013). Some disservices are also evidenced, including decreased water yield (Rutledge et al., 2010), increased erosion if the woody vegetation is harvested (Dymond et al., 2012), reduced pasture and crop production by taking up space and using light and nutrients (Dymond et al., 2012), and increased vertebrate pests that degrade pasture and cropland, are vectors for livestock diseases, and prey on native biodiversity (Moller et al., 2002). Providing multiple ecosystem services through woody green infrastructure is an important strategy for achieving multifunctional agriculture (Stobbelaar and van Ittersum, 2009) that secures conservation, a social license to farm, and market access for ethical food and fiber production (Merfield et al., 2015), while increasing agricultural resilience to climate change (MPI, 2015).

Scholars are concerned farmers are removing woody vegetation when they intensify farming systems (Moller et al., 2008). New Zealand's neoliberal policies dictate a voluntary approach to encouraging multi-functional farming, rather than a regulatory publicly-funded one (Craig et al., 2013). Territorial Local Authorities (TLA) work with the dairy industry to implement Resource Management Act (1991) policies to ensure landowners "avoid, remedy or mitigate" adverse effects on the land and water (RMA 1991, Sec. 17(1)). They promote best practice, and offer cost sharing programs. Section 6(c) RMA 1991 requires TLAs to protect areas of 'significant' indigenous vegetation and habitats of indigenous fauna (Norton and Roper-Lindsay, 2004). However, this protects larger patches than on farms (Blackwell et al., 2008), and disregards introduced, or exotic, woody vegetation that provide significant ecosystem services (Craig et al., 2013). There are no policies requiring, or encouraging, its restoration where absent (Morgan, 2000).

Most studies exploring farmer attitudes and behaviours have focused on farmers rather than dairy farmers, native woody vegetation rather than introduced, and its conservation, rather than its restoration. Studies evaluating voluntary regulatory approaches for planting trees demonstrate landowner support for tree planting when they attribute sufficient private values to their products and services (Bradshaw et al., 1998; Fairweather, 1996; Mead, 1995; Rauniyar and Parker, 1998; Underwood and Ripley, 2000; Vokoun et al. 2010). In New Zealand, studies indicate rangeland farmers value trees for sheltering stock, and in areas unsuitable for pasture (Bradshaw et al., 1998; Wilson, 1992). A minority of farmers also value their aesthetic services (Fairweather, 1996), and appreciate their soil conservation services (Mead, 1995). Primary barriers to planting trees are time and money (Fairweather, 1996; Rauniyar and Parker, 1998; Rhodes et al., 2002; Underwood and Ripley 2000). Some studies indicate financial incentives are inadequate to encourage farmers to take land out of production to plant trees (Duesberg et al., 2013).

There is an urgent need for in-depth investigation of farmers' current management of woody vegetation on New Zealand farms: Are woody vegetation networks changing in composition, distribution, and area under voluntary agri-environmental programs and to what effect? Are networks helping to mitigate dairy farming impacts? Are woody vegetation ecosystem services motivating farmers to plant? What are key barriers and enablers to farmers plating woody vegetation? How might farmers be incentivized to plant more, and agri-environmental programs improved to promote high functioning networks?

This paper reports on the efficacy of New Zealand's voluntary agri-environmental program for conserving and restoring woody vegetation within intensive dairy rangeland landscapes by exploring attitudes and behaviours of dairy farmers regarding woody vegetation on farms. Recommendations for improved approaches are provided.

2. Methodology

2.1 Questionnaire and Study population

A six-page mail survey was sent in 2008 to 1,993 dairy farmers chosen from the AsureQuality database using a stratified random sample of 140-159 farms from each main dairy farming region. Farmers surveyed included conventional and organic dairy farms. The average dairy farm size in New Zealand at the time of the study was 172 ha (Statistics New Zealand, 2007), whereas the average farm size of the 457 respondents was 219 ha. The difference probably arose because full-time farmers have larger farms, and tend to respond to surveys more often than part time farmers (Fairweather et al., 2009). Respondents who owned more than one farm were requested to answer the survey in consideration of their largest farm. Respondents provided information on their age, level of formal education, farm and off-farm income, and farm size.

The questionnaire contained mostly closed questions that asked respondents to select an answer from a list; however, farmer attitudes regarding shelterbelts and hedges were measured by averaging responses on a five-point Likert-type scale to 13 statements. The questions focused on native vegetation remnants, shelterbelts and hedges, and woody vegetation associated with steep slopes, wetlands and riparian corridors. We focused on management of indigenous and exotic woody vegetation values and management separately because each has different implications for ecosystem services in production landscapes. Shelterbelts are defined as consisting of one or more rows of trees, while hedges are defined as consisting of one or more rows of shrubs. Wetlands are defined according to the New Zealand Resource Management Act (1991). The response rate per region ranged from 19 to 32% of farmers sampled, and averaged 25.3%, about the same as other surveys of New Zealand farm populations in recent years (Connelly et al., 2003).

2.2 Data analysis

We categorized reasons farmers plant by costs and benefits of private versus public ecosystem services. Private services are rival and excludable and their value can be captured in the marketplace (Kroeger and Casey, 2007). For example, many production services, such as provision of firewood are private ecosystem services. Public services are non-rival and non-excludable, and their value cannot be easily captured (Kroeger and Casey, 2007).

Statistical analyses were undertaken in Genstat 16th Edition; VSN 2013. Logistic regressions were used to test the relationship between whether or not trees or shrubs were planted in the last five years and these predictor variables: 1) the region; 2) size of the farm; 3) age of the farmer; 4) farm income; 5) non-farm income; 6) willingness to pay increased income tax to support tree planting; 7) awareness of tax reductions for planting; 8) the importance of 11 features of shelterbelts i.e. provision of shelter from wind, shade, fodder, timber, erosion control, increased numbers of natural enemies of pest insects, refuge for pests and weeds, habitat for Bovine Tuberculosis vectors, habitat for native birds, habitat for introduced bird, and aesthetics ('looking nice'); and 9) two practical constraints, i.e. impact on pasture production and shelterbelt maintenance costs. The 13 variables in group 8 and 9 above were entered as binary predictors derived from Likert scales i.e. 1 = 'very important' or 'important', compared to 0 = neutral, 'unimportant' or very unimportant'). .

A second set of logistic regressions were used to test the relationship between whether farmers had or had not removed shelterbelts in the last five years, using the same predictor variables and (a) the area of native woody vegetation (excluding Manuka (*Leptospermum scoparium)* and kanuka (*Kunzea ericoides*)) on the farm, and the farmers stated preference for (b) native compared to exotic species, (c) broadleaf compared to confer species, and (d) mixed or single species in shelterbelts. Both logistic regressions were simplified by stepwise reduction to find the most parsimonious model that retained significant predictors. Weak but non-significant region effects may have been present, so the two models were reconstructed in a general linear mixed model with region as the random component of the model to reflect the stratified random nature of the sample selection. This second step allowed prediction of the mean probability of planting trees or removing shelterbelts for significant predictor variables.

To analyse Likert scale data, to determine how important shelterbelt/hedge features and functions are to dairy farmers, medians were calculated for each feature or function. To determine the level of consensus among farmers in support of these opinions, inter-quartile ranges (IQR) were calculated. To account for the ordinal scales involved, differences in the Likert scale responses were tested by Wilcoxin matched-pairs tests, or Chi-squared contingency table tests of associations between factors.

3. Results

3.1 Constraints and enablers for planting woody vegetation

Approximately 65 percent of respondents had planted woody vegetation on their farm within the five years prior to the study (95% binomial confidence interval = 58-67%). Our Logistic regression models discovered significant associations between an increased probability of planting trees and the importance the farmer ascribed to aesthetics (P<.001). They also found a decreased probability of planting when at least part of the farm was irrigated (P = .009) (i.e. farmers that felt that trees interfered with irrigators). In addition, they also found a decreased probability of planting among farmer who considered the cost of maintenance of shelterbelts significant (P = .042). There was also a weak relationship between a decreased probability of planting and increasing farmer age, particularly among famers over 80 (P - .029) (Appendix A, Table A.1).

Amongst those who did not plant woody vegetation, 76% cited associated costs (both financial and time required) deterred them. The cost of fencing was the most frequently cited reason (38% of respondents), followed by the cost of plantings, including labour (32% of respondents), and maintenance of plantings and fences (24% of respondents), “The trees kept falling down, and the maintenance and labour costs were too much (F13).” Approximately 54% of these respondents indicated they did not think planting trees provided them with sufficient benefits to offset their costs, “We are happy with what we have got. We have left the trees in place for protection (F8).” In addition, about 31% said they do not have space for planting, or are unable to accommodate it after introducing new irrigation systems, “They get in the way of my irrigators (F14).” (Figure 1).

Figure 1 Reasons for not planting woody vegetation in the last five years by percentage of farmers not planting. Costs associated with fencing and planting are key barriers, in addition to insufficient benefits.

Our logistic regression models also found that farmers who think the aesthetics of their shelterbelts are important, erosion control is important, and have a preference for single species shelterbelts, are significantly more likely to have removed their shelterbelts in the last 5 years. Farms with more than 5 hectares of native forest were less likely to have removed shelter than those with only small fragments remaining. In addition, farmers of larger farms are more likely to have removed shelterbelts than those farming smaller areas (Table A.2 Appendix 1).

Farmers removed shelterbelts for two main reasons: 1) they lost their ecosystem services, and 2) to increase the productivity of pastures. These two reasons accounted for 55% and 45% of reasons, respectively. Farmers said the loss of service was due to their shelterbelts being old (83% of loss), hazardous (10%) and weedy or ugly (7%). For example, one farmer said, “It was very expensive to maintain, particularly after a storm, and provided minimal stock shading (F7).” In terms of removing shelterbelts to increase pasture productivity, farmers said they removed them to incorporate pivot irrigators (35% of reasons), incorporate fencing (25%), increase pasture production (22%), and increase field sizes (19%). For example, one farmer said, “We wanted to change the paddock size and it (*the shelterbelt*) was in the way (F5).”

3.2 Locations of newly planted woody vegetation

The majority of farmer plantings are focused around waterways (34%), wetlands and ponds (28%) and on steep slopes (24%). A small amount (12%) are within field margins, alongside roads and driveways, and the remainder (2%) are planted adjacent to structures (e.g. silage bunks and sheds), and in existing areas of native forest (Figure 2).

Figure 2. Location of plantings in last five years by percentage. New plantings are concentrated near waterways, wetlands and on steep slopes.

3.3 Amounts/Sizes of existing indigenous vegetation, and newly planted woody vegetation

A majority of dairy farmer respondents (67%) had existing patches of indigenous woody vegetation less than 5ha in size at the time of the study. Twenty two percent of farmers had patches of regenerating native Manuka ((*Leptospermum scoparium)*/Kanuka (*Kunzea ericoides*) scrub greater than or equal to 1 ha, and 58% of farmers had other types of native woody vegetation. These patches occupy a small percentage of dairy farm land (an average of 0.5% to 2.5%).

A majority of new plantings are small in area, with 68% and 78% of waterway and wetland/pond plantings < .9ha, respectively. Plantings on steep slopes tend to be larger, with 54% of plantings < .9ha, and 46% of plantings > .9ha (Figure 3). This latter finding may reflect the greater use of steep slopes for lumber production (Figure 3). Some farmers indicated they focused their new plantings in low pasture production areas. For example, one farmer said, "We have an ongoing program to plant out areas which are less productive, about $7,500 per year (F2)."

Figure 3. Size of plantings in last five years by percentage. Most plantings are < .9 ha in size

A majority (80%) of farmers had shelterbelts and/or hedges. Half of these farmers had only shelterbelts, 37% had both shelterbelts and hedges, and 13% had only hedges. Fifty one percent of farmers did not remove, replace and/or add a hedge or shelterbelt in the last five years. The other 49% were actively changing their shelterbelts. Of these farmers, 6.4% were planting to retain existing shelterbelt functions (without adding or subtracting shelterbelts), with 4.9% removing and replacing their shelterbelts in existing locations, and 1.5% removing them from these locations, but planting them elsewhere. Roughly a third of farmers (28.9%) were increasing their shelterbelt functions through additional plantings, with 23.5% retaining their shelterbelts and planting additional ones elsewhere, and 5.4% removing them, replacing them, and planting additional ones elsewhere. Finally, 13.7% of farmers were removing their shelterbelts. Assuming farmers planted the same area they removed, shelterbelts may be increasing, with more than twice the number of farmers planting additional areas than removing them (Figure 4).

Figure 4 Strategies for managing shelterbelts/hedges in the last five years by percentage of farmers. Assuming equal areas planted as removed, the amount of cover in shelterbelts may be increasing.

3.4 Farmer Ecosystem service goals for Planting Woody Vegetation

Farmers indicated their main goals for planting adjacent to waterways, wetlands/ponds and on steep slopes were to support these public ecosystem services: water cleansing, nature conservation, stock shelter, erosion control, and to a lesser extent, aesthetics. Some farmers wanted to make it clear they received no benefit from their planting, "It makes us happy and satisfied that we are replacing exotic with native vegetation, and we get pleasure from this. We love the native birds. There is no financial bearing on what we plant (F121)." A significant number of farmers who planted on steep slopes also indicated the provision of timber was an important goal (Table 1).

Table 1. Ecosystem service goals by percentage of farmers who planted in last five years by area. Public ecosystem service goals were most frequently cited.

Reasons	Waterways % (#) farmers /392	Wetlands % (#) farmers /299	Steep Slopes % (#) farmers /234
Public ecosystem service reasons			
Water Cleansing	30% (109)	19% (58)	6% (13)
Nature Conservation	20% (72)	25% (76)	18% (43)
Stock shelter	20% (74)	18% (55)	16% (38)
Erosion control	19% (67)	11% (33)	26% (60)
Provision of aesthetic services	11% (40)	14% (43)	10% (24)
Private ecosystem service reasons			
Provision of timber	N.A.	5% (14)	17% (39)
Provision of firewood	N.A.	5% (14)	7% (16)

Provision of fruit	N.A.	2% (5)	N.A.
Provision of fodder	N.A.	.3% (1)	N.A.

Wilcoxin matched pairs tests demonstrate statistically significant differences between the mean rankings of importance farmers attribute to different services provided by shelterbelts/hedges, and to their implementation issues. There is a high level of agreement among farmers that the most important services are the regulation of microclimate (excessive wind and sun), and the provision of aesthetic services. There is also high agreement areas for planting should not reduce pasture production (i.e. do not reduce growth rate or quality of pasture, area of pasture, or interfere with equipment that improves pasture production, like pivot irrigators), and are low maintenance. Although farmers agreed the provision of native bird habitat is an important service, there was less agreement. Farmers attribute significantly more importance to shelterbelts/hedges as habitat for native versus exotic birds ($p<0.001$). Of note is the relatively low importance farmers attribute to the erosion control functions of shelterbelts/hedges, and for providing habitat for beneficial insects that help to reduce pasture pests (Figure 5).

Figure 5. The mean relative importance farmers attribute to shelterbelt/hedge features and functions and the level of consensus among farmers regarding their importance. Wind/shade protection and aesthetics are important design goals for farmers, and shelterbelts/hedges must be low maintenance and not reduce pasture production.

3.5 Type of woody vegetation farmers planted in last five years

Dairy farmers who plant woody vegetation on farmland in the last five years are significantly more likely to plant both native and exotic species, than just natives, or just exotics (X^2 = 9.383, df=2, p =

0.009). While 41% of respondents (115/282) planted both exotics and native species, 26 percent (73/282) planted only natives and 33 percent (94/282) only exotics.

Reasons farmers gave for planting native and/or exotic vegetation in the last five years can be divided into three reason categories: public ecosystem services, private ecosystem services and factors related to shelterbelt/hedge implementation. Farmers indicated they planted native woody vegetation largely because of its public ecosystem services. A majority of farmers (59%) who planted natives did so because they find them more visually attractive than exotic plants, while a small number (2%) of these farmers liked the look of having a mix of natives and exotics. Half of farmers (52%) also planted them because they believed they provide a superior food source for birds. Many farmers (23%) also said they preferred natives without giving a reason, suggesting they did so for ethical reasons. In addition, many farmers (29%) planted natives because they thought they were easier to maintain than exotic plants.

There is less consensus among farmers regarding reasons for planting exotic woody vegetation in terms of their ecosystem services. A significant number indicated they did so for their private ecosystem services. The largest group (32%) said they planted them, at least in part, for their lumber values, and a further 11% said that exotics provided superior shelter for their cattle. A further 19% said they planted them for their superior aesthetics, or because they liked the look of a mix of exotics with native plants. However, the most consensus among these farmers was with respect to their relative ease of implementation. A majority (66%) agreed they grew faster than natives, were cheaper to purchase (29%), and easier to maintain (24%) than natives.

Few farmers stated they planted either exotics or natives for their superior water cleansing, erosion control or, in terms of natives, their provision of superior stock shelter, despite farmers indicating these were among the most important reasons for planting woody vegetation. Similarly, few farmers said they chose either natives or exotics because of the availability of government financing (Table 2).

Table 2. Reasons for planting native and/or exotic plantings by % (#) of farmers who planted in last five years. Natives are largely planted for their public ecosystem services, while exotics are grown for their private ecosystem services and because they are easier to grow, maintain, and are less costly.

Public ecosystem services	**Native**	**Exotic**
Important food for birds	52% (92)	9% (18)
Bee habitat	0%	.5% (1)
Beneficial insect habitat	0%	0%
Water cleansing	0%	0%
Better erosion control	.6 (1)	4% (8)
More visually attractive	59% (104)	19% (41)
Just prefer	23% (41)	0%
Better stock shelter	3% (5)	11% (23)
Private ecosystem services		
Better timber values	4% (6)	32% (66)
Firewood	0%	1% (2)
Produces fruit	6% (10)	6% (12)
Fodder	1% (1)	5% (11)
Implementation factors		
Easier to maintain	29% (51)	24% (50)
Cheaper to purchase	9% (16)	29% (60)
Grows faster/Suits climate	14% (24)	66% (138)
Financial assistance/free seedlings available	4% (7)	3% (6)
Total number of respondents	100% (178)	100% (207)

There was little consensus among farmers regarding preferences for native, exotic or mixed plantings adjacent to waterways or wetlands/ponds. Farmers planted an equal number of all native and all exotic plantings (38% or 67/176 plantings), and a smaller number of mixed plantings (24% or 43/176 plantings) adjacent to waterways. In terms of wetlands and ponds, farmers demonstrated a preference for native plantings, with 44% or 63/143 plantings, and smaller numbers of mixed (30% or 43/143), and exotic only (26% or 37/143) plantings. Steep slopes were the only areas where farmers indicate a significant preference for planting exotics over native plants, with 57% (71/124) of plantings exotic (Figure 6).

Figure 6 Percentage of plantings by area and type planted in the last five years. Many farmers prefer exotic woody vegetation on steep slopes, and native woody vegetation is slightly preferred adjacent to wetlands/ponds.

In terms of shelterbelts and hedges, a majority of farmers said they preferred native, broadleaf and mixed species (Figure 7). There was no significant difference between the preferences of farmers who had planted shelterbelts and hedges in the last five years and those who had not.

Figure 7 Percentage of farmers who prefer natives and/or exotic, conifer and/or broadleaf and single and/or multiple species shelterbelts and hedges. Most farmers preferred native, broadleaf and multiple species.

3.6 Fencing of woody vegetation

Stock requires exclusion from plantings, such as with a fence, to prevent it from damaging plantings and from defecating in waterways and wetlands/ponds which leads to water pollution and degradation of aquatic/semi aquatic habitat. Respondents said that a majority of wetland (84% of plantings), waterway (79% percent) and steep slopes (84%) were fully fenced. A further 14%, 18% and 9% of plantings in wetlands, waterways and steep slopes, respectively, were partially fenced (Figure 8).

Figure 8 Percentage of farmers that fenced, partially fenced and did not fence plantings by area. The differences between sites are statistically significant (p=0.031).

A smaller percentage (56%) of shelterbelts/hedges were fully fenced, with 29% partially fenced and 15% unfenced. Studies indicate fenced shelterbelts increase habitat for beneficial insects, i.e. insects that prey on pasture pests (Fukuda et al., 2011). Of the respondents who indicated that at least some of their shelterbelts were not fully fenced, 62% indicated they would fence their shelterbelts if their regional council paid for 100% of the cost of fencing. On the other hand, 15% of farmers who had unfenced shelterbelts said would not fence their shelterbelts even if fencing was free, and a further 23% percent said they did not know whether they would fence or not. This suggests there may be disservices or costs associated with fencing, or uncertainty about the benefits of fencing. For example, one farmer said, “Shelterbelts can provide cover for pests – stoats, rabbits and possums (f5).”

3.7 Incentives and assistance for planting

3.7.1 Government funding of plantings

An average of 17% of farmers planted their waterways, wetlands, and/or steep slopes with financial support for their planting and/or fencing. Waterways received twice as much funding as wetland/pond and steep slope plantings, with 24% funded versus 12% and 14% funded, respectively. Most (92%) of the funded plantings were fenced, with 6% unfenced and 1% partially-fenced. An average of 57% of funding was less than 30% and an average of 88% was less than or equal to 50% of the cost of planting and/or fencing.

Over half (56%) of farmers said they would be motivated to plant trees or shrubs if free vegetation or labour were provided. However, most of these farmers (89%) indicated they didn't need this much funding to motivate them, indicating support for up to 50% of costs covered would be sufficient (Figure 9). Some farmers said the amount needs to be high enough to offset the time and energy to apply for funding. For example, one farmer said, "I wouldn't apply for $1000, but would apply for $5000. It takes too much time to apply (F7)." Another farmer stated that more help is required to assist farmers to take advantage of these programs, "Regional council may have so called incentives, but you try to find out about them, and their quality, and it's not easy, and often not helpful (F 141)."

Figure 9. Percent of funded farmers by % of funding per area compared with % of funding that would motivate farmers to plant. A small percentage were funded, with most < level required to motivate most farmers.

The other 44% of farmers said they would not be motivated by council offering free plants or labour. A majority of this group (77%) said they would plant trees and shrubs regardless of the financial support, "I would plant regardless, but if an incentive were available, it would be nice (F3)." Some felt it was their responsibility to plant on their farm, not the government's, "I don't expect councils to fund this. It is not their role (F9)." A few farmers also mentioned time was a significant barrier to planting, "Not so much the money, I struggle to find the time. If someone could organize contractors etc., it would be great (F133). "

The other 23% of farmers who said they would not be motivated by 100% financing, and would not plant under any circumstances. Some felt there was no value in restoring more woody vegetation, particularly native bush, on productive farmland and that New Zealand already had enough, "New Zealand has 6 million ha of native bush, one of the most heavily stocked in the world for our size. This obsession with natives is sickening. They take forever to grow, their ugly (unless they are established), and regional council has no right to use rate payers money on such crap incentives (F9).”

There was little evidence of an association between farmer attitudes toward government funding of plants and fencing and decisions regarding whether to plant woody vegetation on farms, or whether to remove shelterbelts or hedges (Chi square test, P>0.62).

3.7.2 Government tax breaks for planting and maintaining woody vegetation

To encourage dairy farmers to mitigate soil erosion and provide shelter in support of animal welfare, New Zealand government (2004) offered farmers a tax break on the establishment and maintenance of trees in support of erosion control and shelter in the years covered by this study. A similar number (between 71% and 75%) of farmers who planted and did not plant knew about the tax break, and there was no association between knowing about the tax break and a decision to plant, or remove shelterbelts/hedges (Chi square test, P>0.62).

Only 13% of farmers are in support of increased taxes to subsidize the costs of planting on private farms, and there was no consensus regarding how much of an increase is desirable. While 50% thought taxes should be raised less than $30 NZ dollars, 50% thought taxes should be raised over $31 NZ dollars (Figure 10). There is no association between farmer attitudes about a tax increase and decisions regarding whether or not to plant woody vegetation, or to remove shelterbelts and hedges (chi square test, p>0.62).

Figure 10. Percentage of farmers who favour a tax increase to subsidize trees on farms by amount of tax increase. There was no consensus among farmers regarding amount taxes should be increased.

Among the 87% of farmers who did not favour a tax increase, was concern that farmers receiving payment would not care of their trees, “No, I don’t favour a tax because if people are paid to plant trees, they may not take care of them (F4).” Others indicated they did not want government involved because it would increase bureaucracy and the cost of planting, “Offering incentives for planting or fencing will just increase the bureaucracy of the councils and also would probably be more costly – all things considered (F435).” Still other farmers said they would like a tax deduction for retaining their native bush, “I want a rates rebate on land planted in native (F3).”

4. Discussion

Are woody vegetation networks changing in composition, distribution, and area?

Historically, woody vegetation networks within many dairy landscapes were extensively planted by sheep farmers and were dominated by exotic, often single species (Mead, 1995), within shelterbelts and hedges. These networks provided vital functions to farmers, including shelter for sheep that are more sensitive to adverse weather than cows (NAWAC, 2014), and stock control (Olson and Holland, 1995). Until fairly recently, there has been limited woody vegetation or fencing in association with waterways or wetlands/ponds (MFE, 2001). The results of this research indicate woody vegetation networks planted by dairy farmers are different in area, configuration and composition than those planted by sheep farmers. Furthermore, they are changing. Farmers are increasingly planting and fencing their waterways, and wetland/ponds, and removing, and sometimes changing the location of their shelterbelts and hedges in response to intensification. Planting on steep slopes, particularly where unsuitable for pasture, continues. Furthermore, the types of plants favoured by dairy farmers has now changed to a preference for natives, broadleaf and mixed species plantings. The results also suggest the total amount of woody vegetation cover is increasing. Farmers are planting in new locations (waterways and wetlands/ponds), and more farmers are adding than removing shelterbelts/hedges. However, this assumes the area being planted is equivalent to that being removed. It also assumes a representative questionnaire sample. One limitation of this study is that only 25% of dairy farmers completed the questionnaire, even if this reflects an acceptable rate of return (Connelly et al. 2003). It is also possible that more farmers favourable to planting completed the questionnaire than farmers unfavourable to planting, thus biasing the results. Research is required to measure actual cover through mapping these areas of vegetation at a fine resolution, and comparing areas with those historical.

Despite this projection of a general increase, the distribution of woody vegetation across these landscapes is changing. Farms with little vegetation remaining are more likely to remove their shelterbelts, and those with larger patches are more likely to retain and plant. This suggests the differences in amount and quality of cover between farms are becoming more extreme. There is a pressing need to evaluate the ecosystem services provided by farms with skeletal, poor quality networks relative to farms characterized by larger, and higher quality networks, to determine their level of service and their acceptability among farming communities, and the public reliant on these services. These farms and landscape components would benefit from targeted government incentive programs and dairy company schemes that ensure woody vegetation networks provide minimum levels of service.

Are the resulting woody vegetation networks significantly contributing to the mitigation of key dairy farming impacts?

The results of this study suggest farmers are aware of the mitigating role of woody vegetation for reducing excessive nitrogen, sedimentation and phosphorus (Parliamentary Commissioner for the Environment, 2013), and for improving support for native biodiversity (Lee et al., 2008). Farmers indicated water cleaning, nature conservation and erosion control were major reasons for planting adjacent to waterways, wetlands/ponds and on steep slopes. However, the extents to which on farm plantings will mitigate water quality impacts and support native biodiversity in the landscape are questionable. Based on a literature view of buffer widths, Parkyn et al. (2000) argued a self-sustaining buffer of non-pasture grass and woody vegetation, requires between 10-20 metres in width where surface water drainage occurs. This width would remove excessive sediment and nutrients, and sustain indigenous vegetation with minimum weeding, given a functional planting design (Parkyn et al., 2000). However, farmers suggest their new waterways, wetland/pond plantings are smaller in size, with 33% less than .1 ha, and 40% less than .9ha. Furthermore, farmers indicated they chose either exotic, native or mixed plants, not for their water cleansing or erosion control functions, but for their importance as wildlife habitat for birds, aesthetic properties, and for their fast growth, low cost and ease of maintenance.

The literature review of Parkyn et al. (2000) indicates that wider buffers are required to support sensitive native wildlife; however, few New Zealand studies have determined functional widths in dairy landscapes (MAF, 2004). Meurk and Hall (2006) argue that even small patch networks have the potential to support New Zealand’s extent wildlife within these landscapes, such as insectivorous birds, lizards and invertebrates. They are small in size or vagile and can be supported by small areas if functionally connected and of sufficient quality (Henle et al. 2004). For example, Meurk and Hall (2006) recommend a network of 6.25 ha patches spaced 5 km apart, supplemented by 1.6 ha patches, spaced 1.2 km apart and .01 ha patches, spaced .2 km apart, to support both sensitive and less sensitive native plants and wildlife. Again, it is questionable whether dairy farm plantings will meet these requirements. The highest quality and largest patches are remnant native vegetation; however a majority of farms have patches less than 5 ha in size. These larger patches could be supplemented by the existing and new plantings on farms; however, it is unclear whether these are of sufficient size, shape, quality, or the necessary distance apart, to provide habitat for sensitive metapopulations. Farmers who plant indicate patches are located and sized largely in response to availability of non-productive land, rather than those necessary to support targeted wildlife. Furthermore, while all farmers say they prefer native, broadleaf and mixed plantings (characteristics more likely to provide higher quality wildlife habitat), many are still planting exotics, conifers and single species due to their lower costs and ease of management.

To improve the performance of woody vegetation on farms, farmers need more information about the benefits and drawbacks of different plants, configurations, sizes and locations for supporting these functions and their benefits and drawbacks for milk production. However, woody vegetation networks that cross individual farm boundaries are required to significantly address both issues (MAF, 2004), and there is a key role to be played by both government and dairy companies in planning and implementing coarser scaled networks.

Are private and public ecosystem services of sufficient value to farmers to motivate them to plant, and are they equally distributed?

Previous studies indicate that without strong and enforced regulations, or effective regulatory or market incentives, landowners are willing to retain remnant native woody vegetation if it is located on land unsuitable for pasture (Bradshaw et al., 1998; Wilson, 1992), and/or when there is significant private net benefit (Bradshaw et al., 1998; Fairweather, 1996; Mead, 1995; Rauniyar and Parker, 1998; Underwood and Ripley, 2000; Vokoun et al., 2010). The results of this study indicate many farmers do not believe woody vegetation provides sufficient benefit to offset its costs, particularly on productive pasture land. While pasture provides high private services tightly linked with milk production, those of woody vegetation are unrelated (e.g. lumber, firewood or berry production). Furthermore, farmers indicate they don't value the production of these products in woody vegetation plantings. Rather, they are planting largely to support public ecosystem service whose values cannot be easily capture in the marketplace for profit (Kroeger and Casey, 2007). A few of these public services are related to dairy production. For example, farmers value the shelter services of woody vegetation, and studies indicate that shade, in particular, increases milk production during hot days (NAWAC, 2014). The other milk-production related service recognized in the literature, is the provision of habitat for beneficial insects that reduce pasture pests (Fukuda et al., 2011). However, there is a lack of consensus among farmers regarding their importance. This may be a reflection of inadequate demonstration of their significance to dairy farming (Jonsson et al., 2008), and/or studies indicating they can provide habitat for vertebrate pests (Ragg and Moller, 2000).

Most farmers are planting to support public services unrelated to milk production, such as water filtration, nature conservation and aesthetics. Previous studies regarding why farmers retain native vegetation on farms also indicate they do so to support public services, such as recreation, aesthetics and nature conservation (Cocklin and Dorman, 1994; Wilson, 1992). Farmers can’t capture the value of these public ecosystem services (and the money they invest in providing them) in the marketplace. As a result, studies indicate farmers do not value them as highly as private production–related services whose values can be captured (Parminter and Perkins, 1997), or even public services that are production related, such as stock shelter (Carr and Tait, 1991; Parminter and Perkins, 1997; Sandhu et al., 2007). Therefore, among many farmers, these services are not considered decisive factors in whether to plant or not (Carr and Tait, 1991; Fairweather, 1996). Farmers who do place a high value on these services are positively correlated with income (Rauniyar and Parker, 1998; Salam et al., 2006; Underwood and Ripley, 2000; Vanslembrouck et al., 2002), education and conservation knowledge (Cable and Cook, 1996; Salam et al., 2006; Vanslembrouck et al., 2002; Wilson, 1992), and weakly correlated with information about incentive programs and funding (Rhodes et al., 2002). Lower values among farmers are negatively correlated with farmer age (Cable and Cook, 1996; Wilson, 1992). However, the results of this study did not find an increased probability of planting with income, education or among farmers who had a preference for natives, or identified nature conservation as a reason for planting. While younger farmers were more likely to remove shelterbelts and hedges, they were also more likely to plant adjacent to waterways, wetland ponds and on steep slopes. The reverse appears to be true of older farmers. Further research is required to evaluate the ecosystem services provided by woody vegetation to farmers, and the extent to which they provide services and products of sufficient value to motivate them to plant. If services and benefits to farmers are insufficient, more effective government and industry incentives to offset disservices and/or reduce costs to farmers are required if more planting is to occur.

What are key barriers and enablers to farmers planting woody vegetation?

Farmers said that cost of plants, fencing, and maintenance, including the time and labour required, were significant barriers to planting trees, and choosing native species for their plantings. While all farmers said they preferred native, broadleaf and mixed plantings, rather than the exotic, conifer and single species plantings that were historically grown (Norton and Miller, 2000), many farmers were still choosing to plant exotic species, conifers and single species. Many farmers indicated exotic plants were lower in cost, faster to grow, and easier to maintain. Farmers all agreed that ease of maintenance of shelterbelts and hedges is important. Maintenance is also a key factor in ensuring woody vegetation plantings maintain their ecosystem services through time. Where it is inadequate, functions become degraded or lost in shelterbelts (Chevasse, 1982; Hawke et. al., 1993; Olson and Holland, 1995), and riparian buffers (Cooper et al., 1995; Nguyen and Downes, 1997). To overcome these barriers to planting, and to planting native plants, and to ensure plantings retain their functions through time, research is required to evaluate farmer maintenance requirements, and identify planting and management strategies that meet farmer while maximizing support for targeted ecosystem services from initial planting through to senescence.

Farmers said they remove their shelterbelts when they lose their aesthetic services. Increasing aesthetic services on farms is also a top reason why farmers plant woody vegetation, particularly adjacent to waterways, and wetlands/ponds. Studies demonstrate the look of the farm, particularly with respect to whether it looks efficient and tidy, is highly influential to farmer decisions (Carr and Tait, 1991; Mead, 1995; Nassauer, 1989; Wilson, 1992;), and that policies and programs that do not meet farmer aesthetic expectations are less likely to be implemented by farmers (Nassauer, 1989). Fairweather (1994) demonstrates the importance New Zealand farmers attribute to appearing to be hardworking, successful, and/or environmentally responsible among their peers and to the public, and that farm appearance is a key way they communicate these traits. Certain elements and characteristics in landscapes serve as visual cues to the traits landowners want to communicate (Gobster et al., 2007; Nassauer, 1992). For example, cropland farmers in the United States demonstrated neatness and care through the use of trees in rows (Nassauer, 1998). Research is required to identify visual cues important to dairy farmers with respect to woody vegetation plantings in order to identify design and management criteria that meet farmer aesthetic expectations through time. In particular, a staged management strategy, involving mixed species and ages, is required to ensure the continuance of shelterbelt/hedge ecosystem services with tree senescence, and to reduce the vulnerability of networks to disease or pest outbreaks that could wipe out single species dominated plantings across whole landscapes. Further research is also required to identify aesthetic properties of dairy farms and landscapes that are genuinely aligned with ecological health. This will assist the dairy industry in promoting clean and green farming practices to the public and the dairy marketplace, while reducing the risk of landscape greenwashing – the development of landscapes that appear to be healthy, but are not (Gobster et. al., 2007; Nassauer, 1992).

How might farmers be incentivized to retain or restore woody vegetation to support multifunctional agriculture?

The existing regulatory incentives for planting and fencing are not motivating the majority of farmers to plant and fence largely because most farmers do not think they are significant. Furthermore, farmers are wary of government dictating their farming decisions, and some feel that funding programs are inaccessible, and not cost effective. As a result, relatively few farmers are taking advantage of these either tax breaks, or funding programs. Farmers that said they would be motivated to plant if significant funding were provided, indicated they would require up to 50% of costs covered. New Zealand farmers may be motivated by a government funding program such as Australia’s 20 Million Trees which has motivated the planting of more than 11 million trees, with targeted funding to grantees of between $20,000 and $100,000 for native plants and, particularly, to those providing habitat for threatened species (Australia Department for Environment, n.d.). A similar New Zealand program could be targeted to farmers, and farmers within dairy landscapes, with particularly low cover, or toward farm areas where ecosystem service benefits are highest and/or costs of planting lowest.

5. Conclusion

The findings indicate New Zealand’s current neoliberal policy approach, relying on individual farmers to voluntarily conserve and restore woody vegetation on their farms, is not sufficient to ensure the development of high functioning green infrastructure networks in support of multiple ecosystem services and multifunctional dairy production. While the total area of woody vegetation appears to be increasing within dairy landscapes, it is being reconfigured and redistributed. Farms having very little are losing even more, and those with more are gaining woody vegetation. The impacts of these changes on valuable public ecosystem services both locally and across landscapes are unknown. While many farmers are planting new areas with the goal of providing public ecosystem services, including water cleansing, and increased support for native biodiversity, the location and design of plantings do not appear to support these functions.

To improve New Zealand's voluntary agri-environmental program, the woody vegetation ecosystem services of value to farmers need to be more effectively demonstrated. Woody vegetation planting and management plans, particularly those with native plants, need to be developed that are low cost, fast growing and easy to maintain. Plantings that maximize aesthetic services on farms while performing other key services that improve the health of the landscape would also encourage farmers to plant, particularly those signaling clean, productive, tidy and efficient dairy farming. Government incentive programs that provide at least 50% of initial funding particularly with respect to targeted areas that provide greatest benefit at least cost may also increase tree planting among farmers.

Improved farm-scaled programs for restoring woody vegetation in dairy landscapes will make a valuable contribution toward the development of multifunctional agriculture in New Zealand's dairy landscapes; however, government and industry leadership are required to plan and implement the course scaled woody green infrastructure required to significantly improve water quality and support native biodiversity across farm boundaries.

Appendix A

Table A.1 Regression explanatory variables predicting probability woody vegetation planted in the last 5 years.

Variable	**t pr.[1]**	**Predicted pr. Planted[2]**
Aesthetics not important = 0		0.32
Aesthetics important = 1	<.001	0.58

Maintenance costs not important = 0		0.56
Maintenance costs important = 1	0.009	0.34
Farm is not irrigated = 0 At least part of farm irrigated = 1	 0.042	0.53 0.37
Age group 22-29		0.69
Age group 30-39	0.152	0.43
Age group 40-49	0.324	0.52
Age group 50-59	0.408	0.55
Age group 60-69	0.166	0.44
Age group 70-79	0.164	0.41
Age group 80-88	0.029	0.16

[1] t test for the parameter explaining variation in probability of having planted in last 5 years

[2] Back transformed predicted mean probability of having planted in last 5 years, using GLMM with region as a random blocking variable

Table A.2 Regression explanatory variables predicting probability woody vegetation planted in the last 5 years.

Variable	**t pr.[1]**	**Predicted pr. removed[2]**
Aesthetics not important = 0	Base	0.14
Aesthetics important = 1	0.068	0.23
Age group 22-29	Base	0.38

Age group 30-39	0.404	0.25
Age group 40-49	0.146	0.16
Age group 50-59	0.243	0.19
Age group 60-69	0.33	0.21
Age group 70-79	0.028	0.04
Age group 80-88	0.54	0.22
Erosion = 0	Base	0.15
Erosion = 1	0.028	0.23
Neither preferred	Base	0.11
Preferred mixed	0.173	0.18
Preferred single	0.006	0.30
No native vegetation	0.458	0.21
<0.10 ha native vegetation	0.986	0.24
0.1-0.9 ha native vegetation	Base	0.25
1-5 ha native vegetation	0.326	0.19
>5 ha native vegetation	0.003	0.08
Farm size (ha)	0.01	0.001221[3]

[1] t test for the parameter explaining variation in probability of having removed shelterbelts in last 5 years

[2] Back transformed predicted mean probability of having removed shelterbelts in last 5 years using GLMM with region as a random blocking variable.

[3] Slope fir increases in probability of having removed shelterbelts per additional hectare of farm on the logit scale.

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