D.Mackay (2017). Farmer perspectives of the on-farm and off-farm pros and cons of planted multifunctional riparian margins. Land Use Policy. 61:160-170. doi.org/10.1016/j.landusepol.2016.10.053

Title

Farmer perspectives of the on-farm and off-farm pros and cons of planted multifunctional riparian margins

Abstract

The planting of riparian margins is a policy option for pastoral farmers in response to land use induced environmental issues such as declining water quality, stream bank erosion, and loss of aquatic and terrestrial habitat. We elicited the views and experiences as to pros and cons of planting riparian margins from two sets of dairy farmers from Taranaki, New Zealand: those who are or have planted riparian margins, and those who have not yet done so. Those farmers who have planted riparian margins identified 21 positive aspects of riparian margin plantings and 11 negative aspects of riparian margin plantings. Perceived benefits identified by this group include water quality, increased biodiversity, the provision of cultural ecosystem services, immediate direct benefits to farm management and the farm system, and in some instances increased productivity on-farm. In contrast, those farmers that had fenced but not planted their riparian margins did not consider that riparian margin plantings could add further benefits to that which could be achieved by excluding stock from waterways, and associated only negative perceptions with riparian margin plantings. Planting riparian margins is not cost neutral and will not deliver anticipated environmental benefits in every situation. However, we argue that riparian margin plantings are an important ecological infrastructure investment that needs to be captured within a wider policy framework, the benefits of which extend beyond the mitigation of a single negative externality generated by land use practices, such as nutrient loss, and contribute to a multifunctional landscape.

Keywords:

Ecosystem services; environmental policy; natural capital; pastoral farming

1. Introduction

Conversion of forested landscapes to provide for the development of agriculture has occurred throughout the world (Tanentzap et al., 2015). While this whole-scale transformation of landscapes has increased food production, it has come at a cost to system functions, many of which underpin the provision of other ecosystem services which food and water security and human health are also reliant upon (Bommarco et al., 2013; Costanza et al., 2014; Gordon et al., 2010). Spatial separation of land used for food production, from land used for other ecosystem services including biodiversity protection (i.e. land sparing (Fischer et al., 2008)) has reduced social-ecological flexibility of agricultural landscapes by favouring food production in most cases at the cost of all other functions (Meadows et al., 2008). Emphasising productivist notions of land use restricts the transition to multifunctional landscapes (Wilson, 2008).

In agricultural landscapes, land management interventions aimed at improving diversity are increasingly being regulated or otherwise incentivised to mitigate the environmental impacts of agricultural practices and facilitate transitions to greater 'multifunctional agriculture' (Wilson, 2009). An example of an intervention is using riparian zones to separate agricultural practice from waterways. Riparian zones (herein riparian margins) are the margin of land adjacent to waterways where direct interaction between terrestrial and aquatic ecosystems occurs. Riparian margin habitat

is not found anywhere other than the riparian zone and has a disproportional influence on ecosystem function relative to the size of the catchment (Collier et al., 1995).

Functioning riparian margins are the source of ecological processes such as filtering the flow of nutrients and provision of organic input into aquatic food webs (Bennett et al., 2014). Utilising riparian margins as production land heavily compromises their ecological functionality, and removes the ability to spatially separate the detrimental impacts of land use from the receiving environment. The exclusion of livestock from riparian margins and waterways can have immediate environmental benefits (Parkyn et al., 2003) by protecting banks from erosion and waterways from the direct input of nutrients and bacteria. Retired, grassed riparian margins of an adequate width for local soil and slope variables also provide a buffer to the input of sediments, nutrients, pathogens, and pesticides transported by overland flow into waterways, reducing contaminant and sediment loadings in-stream (Collier et al., 1995). While retired single-tier grassed margins create beneficial buffers, diverse, multi-tiered riparian margin vegetation builds on and enhances the benefits provided by grassed margins increasing both riparian margin functionality and in-stream values (DairyNZ, 2012). Multi-tiered riparian margins additionally buffer flood flows and reduce their effect in-stream, maintain a microclimate, increase terrestrial and in-stream habitat, structural complexity, and biodiversity, increase terrestrial carbon inputs into the aquatic system, maintain food webs, and provide shade which maintains lower summer maximum in-stream temperatures and prevents nuisance plant growth (Collier et al., 1995; Moller et al., 2008).

Management of riparian margins is considered to provide a public benefit (Buckley et al., 2012; Cooper et al., 2009) and is increasingly becoming embedded in policy and industry standards internationally, including in Europe under The European Union Nitrates and Water Framework Directives; in Ireland under the Agricultural Environmental Options Scheme; and in New Zealand under the Sustainable Dairying: Water Accord. Beyond the public benefits generated by riparian margins there is evidence to suggest planted riparian margins also provide a wide range of ecosystem services directly useful on-farm (a private benefit). The ability for incentives to effect change depends in part on the strength of the incentive farmers require to adopt a new practice (Pannell, 2004). Recognising that integrating riparian margins into the farm system can self-generate incentive through the provision of private as well as public benefits is therefore critically important for developing policy or industry practice change incentives.

Programmes to reinstate lost vegetation are driving landscape transformation and manipulation of system function. We were principally interested in benefits and values that farmers perceive or experience to be associated with riparian margin plantings on their farms, and how these values are linked to farmer willingness and motivations to plant riparian margins or not. To better understand these values, we invited dairy farmers from Taranaki, New Zealand to participate in half-day workshops to explore their perspectives on the pros, cons, benefits, values, and liabilities arising from the reinstatement of woody vegetation within riparian margins. In particular we aimed to answer the following three questions:

1. What values, benefits, costs, constraints, and liabilities (pros and cons) do farmers perceive to be associated with the planting of riparian margins?
2. What do farmers see as the influence of planted riparian margins on the operation of the farm and its biological and financial performance?
3. How do identified values influence farmer's motivations for planting riparian margins and are there additional motivational factors?

Knowledge of the private-public benefits experienced by farmers can assist in refining current or developing future policy-driven land management interventions.

2. Methods

2.1 Riparian margin management in New Zealand

The reintroduction of vegetation (natural capital stocks) is a necessary component of replacing lost biological and structural diversity across large areas of New Zealand as historic and contemporary agricultural practices have led to substantial loss of native vegetation (Ewers et al., 2006; Lee et al., 2008; Myers et al., 2013; Walker et al., 2006). Native landscapes in lowland New Zealand have been almost completely replaced with systems dominated by exotic species introduced from the Northern Hemisphere by European settlers from the early-mid 1800s. While exotic dominated systems can deliver most functions and services necessary for food production, this shift has come at a cost to the provision of other ecosystem services. Intensification of farming practices over recent decades has accelerated the shift towards single-use landscapes where food provision is favoured over other services.

123 There is currently no overarching regulatory obligation or subsidised incentive
124 scheme to compel or encourage New Zealand farmer's to exclude riparian margins
125 from the productive areas of their farm systems (Tanentzap et al., 2015). The statutory
126 responsibility for controlling land use sits at the local government level administered
127 by regional councils. Local government driven riparian margin management in New
128 Zealand typically involves the retirement of the margin from the farm system, or 'set-
129 back' requirements for several land use activities involving discharges into the
130 environment such as the application to land of herbicides, pesticides, fertilisers, or
131 effluent. Retirement of margins is typically focused on dairy systems, horticulture,
132 and commercial forestry while set-back restrictions for discharges can also apply to
133 other farm systems (e.g. sheep and beef). The width of a retired riparian margin varies
134 greatly between regions and between farms and is often a farmer-negotiated distance
135 that can be as narrow as < 1 m, and is often determined independent of the influence
136 of adjacent slope characteristics. Under some policies or programmes, the
137 management of riparian margins may also include planting native riparian vegetation,
138 and it is this activity that our study focuses on. Local authorities (regional and
139 territorial councils) also have responsibilities for the protection and maintenance of
140 existing remnant native vegetation on-farm, including riparian margin vegetation in
141 some cases. However, these approaches are highly variable (Maseyk and Gerbeaux,
142 2015) and there remains no national policy to retain or increase native vegetation
143 (Welsch et al., 2014).
144
145 The industry-led initiative, 'Dairying and Clean Streams Accord' (Clean Streams
146 Accord) was signed by Fonterra (New Zealand's largest dairy cooperative), the
147 Ministry for Agriculture and Forestry, the Ministry for the Environment, and Local

148 Government New Zealand in 2003. The Clean Streams Accord operated at a national
149 level to address the environmental impacts of dairy farming on waterways and
150 included targets for stock exclusion, and effluent and nutrient management. The Clean
151 Streams Accord was replaced by the 'Sustainable Dairying: Water Accord' (the Water
152 Accord) in 2012. While sitting outside of legislative requirements, compliance with
153 the Water Accord is mandatory as an industry condition of supply.
154
155 2.2 States of riparian margins
156 We conceptualise three typical states of riparian margins: *1. Farmed*, margins are
157 utilised for farm productivity (e.g. cropping or grazing livestock to the waters edge);
158 *2. Retired*, productivity is separated from the riparian zone leaving a single-tier
159 ungrazed grass strip; and *3. Retired and vegetated*, multi-tiered riparian margin
160 habitat including a diversity of plant forms is established and maintained. Relative
161 functionality (environmental, productive, and social) increases from state 1 to state 3,
162 although complete restoration of ecological riparian function is uncertain (Parkyn et
163 al., 2003; Stockan et al., 2012), is a long-term prospect (Collier et al., 1995; Stockan
164 et al., 2012), and is influenced by the spatial arrangement and scale of planted reaches
165 (Parkyn et al., 2003).
166
167 2.3 Study site
168 The study was based within the 723,610 ha volcanic ring plain of Mt Taranaki in the
169 Taranaki Region, west coast of the North Island, New Zealand. Following European
170 settlement in the mid-1800s, the once forested landscape was rapidly and almost
171 entirely developed into a largely homogenous pastoral landscape with small,
172 fragmented, isolated remnants of native wetland, scrub, and forest. This

173 transformation is similar to that experienced elsewhere in New Zealand and globally
174 (Welsch et al., 2014). Native biodiversity on the Taranaki ring plain has been reduced
175 to less than 10% of former cover and continues to decline (Lee et al., 2008; TRC
176 2008, 2014). This historic and contemporary loss of diversity from the ring plain has
177 caused the irreversible loss of many of the native biodiversity elements and associated
178 ecosystem services that would have been provided by a more diverse landscape.
179 Pastoral farming operations on the ring plain are of an intensity that effectively
180 prevents unassisted reestablishment of lost biota. Over 300 short reach (average
181 length of 20 km), high gradient waterways radiate from Mt Taranaki flowing rapidly
182 and steadily into the Tasman Sea. This extensive network of waterways has a total
183 length of 7,330 km (14,660 km of stream bank), with a total of 6,517 km (13,034 km
184 of stream bank) on the ring plain (TRC 2011).
185
186 2.4 The Taranaki Riparian Margin Management Programme
187 In 1993 Taranaki Regional Council (TRC) initiated the 'Taranaki Riparian
188 Management Programme' (Taranaki programme), a voluntary regionally-focussed
189 riparian margin planting programme targeted at dairy systems on the ring plain, with a
190 key objective to 'protect the water quality in Taranaki'. The Water Accord also
191 applies to dairy farmers in the Taranaki Region, thus there are two major riparian
192 margin programmes co-existing in Taranaki. While both are non-statutory, there are
193 several differences in their design. Of most relevance here are: 1) the reach of the
194 Taranaki programme is greater than the Water Accord with all streams (down to 1st
195 order streams) and all riverine wetlands captured by the programme, while the Water
196 Accord applies only to waterways greater than one metre in width and deeper than
197 30 cm and only 'regionally significant' wetlands; 2) the Taranaki programme is

198 focused on fencing and planting while the Water Accord focuses on stock exclusion
199 via fencing; 3) the Water Accord includes actions beyond riparian margin
200 management (e.g. management of nutrient loss, and implementation of nutrient use
201 efficiency) that is not part of the Taranaki programme; 4) under the Water Accord,
202 dairy companies have committed to develop support tools (such as guidelines), while
203 under the Taranaki programme, the regional council prepares a riparian planting plan
204 at no cost to the farmer, facilitates supply of plants, and provides plants at wholesale
205 costs. Critically, the Water Accord carries with it the threat of penalty as under the
206 condition of supply agreement, dairy companies can cease to collect milk should
207 farmers not comply with targets.
208
209 Of the total 13,034 km of stream bank on the ring plain, 11,093 km has been fenced
210 (85%) and 2,138 km (16%) planted under the Taranaki programme. Combined with
211 existing vegetation, the new plantings bring the total combined length of vegetated
212 riparian margins across the ring plain to 6,874 km (53%).
213
214 2.5 Farmer workshops
215 *2.5.1 Selection of participants*
216 Our study group comprised dairy farmers farming on the Taranaki ring plain (from a
217 total population of ~1760 dairy farmers in the Taranaki Region). Eligibility for
218 participation was simple:
219
220 1. A dairy farmer farming on the Taranaki ring plain that had planted or was in the
221 process of planting riparian margin vegetation (Group A), or

2. A dairy farmer farming on the Taranaki ring plain that had not planted riparian margin vegetation (Group B).

Beyond these criteria, no preference was made based on any other characteristic. The two farmer groups participated in the study via two workshops (one for each group) held in Stratford, Taranaki Region in May 2015.

A total of twenty-two farmers attended the workshops, 17 in Group A and five in Group B. One rural professional (who had previously been dairy farming) also participated with Group A (bringing Group A participants to 18).

2.5.2 Workshop design

We were interested in farmers' perspectives on the environmental, social, and production values provided by riparian margin management and their motivations for planting riparian margins. Workshop activities were designed to answer the research questions.

Facilitated discussions followed a mixed-method approach including semi-structured break-out group and whole-group discussions and feedback, and structured voting methodologies (open and blind) to elicit responses from participants. The definition of riparian margins was presented during the introduction of both workshops to establish consistent context amongst participants and between workshops. Discussions were prefaced with a brief presentation and parameterisation of the topic for discussion and their duration time-restricted (between ten minutes and half an hour), but not obstructed otherwise. Before breaking into discussion groups, participants were asked

247 to reflect on the topics raised in the previous discussion. In this way, each subsequent
248 discussion advanced the prior and allowed for further detail to emerge.
249
250 Workshop with Group A
251 Following an initial discussion and feedback session participants were each allocated
252 three votes which they used to indicate three aspects of riparian margin plantings from
253 the list generated during the group discussions that they felt best captured what was
254 most relevant to them. Voting was open and conducted as a group exercise. This
255 exercise produced the 'top ten' responses that were of most relevance to the group as
256 a whole. Following the workshops, the responses were evaluated to identify thematic
257 similarities and retrospectively grouped into categories (Table 1). Each comment was
258 assigned to one of nine categories. Negative comments were taken to represent 'cons'
259 and positive comments to represent 'pros' within each category.
260
261 To further gauge variance in opinion between participants, the language of the top ten
262 responses from the first discussion (pros and cons of riparian margins) was refined to
263 remove potential ambiguity and transposed into statements (the focal statements)
264 (Table 2). Participants were then asked to indicate their level of agreement with each
265 of the ten focal statements using a five-point fixed Likert scale (5, Strongly agree, 4,
266 Agree, 3, Neutral, 2, Disagree, 1, Strongly disagree). This exercise was conducted
267 'blind', using interactive Turning Technologies software (TurningPoint version 5.3.1)
268 and hand-held voting clickers (Turning Technologies, ResponseCard RF LCD). This
269 method allowed the votes to be confidential, addressing any potential peer pressure
270 and maintaining independence from the group dynamic.
271

272 Finally, participants were presented with a questionnaire investigating why farmers
273 had planted riparian margins and how they felt about them. The questionnaire
274 proposed 26 fixed statements of which the respondent could tick as many as they
275 agreed with. Respondents were also given the option for a 'don't know' response or to
276 provide their own statement(s). Sixteen participants completed the questionnaire.
277 Responses to the questionnaire were summarised with descriptive statistics.
278
279 Workshop with Group B
280 The Group B workshop followed the same format as that for Group A. Following
281 their own discussion, response feedback, and preference voting on the pros and cons
282 of planting riparian margins, Group B were presented with the focal statements
283 generated during the workshop with Group A. Group B participants were then asked
284 to indicate their level of agreement with each of the ten focal statements using the
285 same five-point fixed Likert scale (Strongly agree, Agree, Neutral, Disagree, Strongly
286 disagree) and blind polling methodology. Comparison between the two groups of the
287 level of agreement with the ten focal statements was conducted using Pearson's t-tests
288 conducted using R Studio version 0.98.1091 (R Core Team, 2014).
289
290 2.6 Online surveys
291 To gauge how representative the responses generated by both workshop groups was
292 of the wider Taranaki ring plain dairy farming community, the views of the TRC
293 Land Management Officers (LMOs) were elicited via an anonymous online survey.
294 The LMOs are directly involved on a day-to-day basis with implementing the
295 Taranaki programme and are regularly engaged in discussions with farmers regards
296 the merits or otherwise of riparian margin plantings. The LMOs were asked to

297 indicate how frequently (All the time, Frequently, Infrequently, Never) they heard
298 each of the ten focal statements derived from responses generated by Group A and all
299 of the responses generated by the Group B (n = 15). Respondents were also given the
300 option for a 'don't know' response or to provide their own comment(s). The online
301 survey was emailed to seven potential participants (four current LMOs and three who
302 were recently but are no longer working as a LMO with the TRC). Four responses
303 were received. While the sample size of the LMO survey is small, each LMO interacts
304 with a large number of farmers on a regular basis. Responses to the online survey
305 were summarised with descriptive statistics and evaluated alongside the outcomes of
306 the farmer workshops.
307
308 **3. Results**
309 There was a notable difference in how each group perceived riparian margins.
310 Group A always assumed plantings to be present when they conceptualised riparian
311 margins, while Group B explicitly differentiated between fenced, single-tier grass
312 strip riparian margins and planted or multi-tier riparian margins and considered the
313 difference to be critical in their assessment of the potential for riparian margins to
314 generate benefits.
315
316 Group A identified 32 pros and cons of planted riparian vegetation while Group B
317 identified 15. Group A's list covered a broader range of aspects that could be
318 aggregated into nine categories (Table 1), while Group B's list only populated four of
319 the same categories. Group A's list predominantly identified positive aspects (pros,
320 65%) while Group B's list contained only negative aspects of riparian margin
321 plantings (Figure 1). The notable disparity between the two groups reflects the general

consensus of Group A that riparian margin plantings provide benefits beyond just the protection of water quality values ("*Riparian plantings make you think about management in a broader way"*) while Group B struggled to identify benefits additional to those achieved by excluding livestock from waterways, openly questioning the ability of plantings to protect water quality ("*Goals are unrealistic and unattainable*").

The ten focal statements derived from responses generated by Group A are presented in Table 2. The farmers in Group A (n = 17) took part in the Likert voting on the focal statements, returning a total of 168 (of the 170 potential) responses (only 16 participants responded to two of the statements). Group B returned a total of 50 responses (all five participants responded to each of the ten statements).

Group A participants showed a tendency to Strongly agree (71, 42%) or Agree (77, 46%) with the group generated statements although some individuals were Neutral (18, 10%). Disagreement with the statements by Group A participants was minor with only two (1%) Strongly disagree responses. Group B participants' responses were more evenly spread across the levels of agreement (Strongly agree, 11 (22%); Agree, 8 (16%); Disagree, 9 (18%); Strongly disagree 9 (18%)) with the highest proportion of responses falling into the Neutral category (13, 26%). However, a significant difference in level of agreement between the two groups was detected for five of the ten focal statements (Figure 2).

3.1 Farmer perceived pros and cons of planted riparian margins (Q1)

346 The range of pros and cons identified by Group A include environmental, social, and
347 production values (Figure 3). Productivist benefits included gains in the management
348 of livestock (including animal welfare), pasture growth, water quality and supply, and
349 reduced labour costs. Long-term management of plantings was identified as a
350 liability, and loss of production land and increased pest and weed control were
351 identified as some of the associated costs. Participants connected riparian margins
352 with environment benefits such as improved water quality (reduced nutrification and
353 reduced sedimentation) and ecological values such as increased terrestrial and aquatic
354 habitat. Social values were also identified as flowing from planted riparian margins
355 including improving the farm appearance, the ability to attract better staff, and
356 increased property values. Several of the pros and cons identified also arise with
357 fenced-only grass-strip riparian margins (Figure 3).
358
359 The enhancement of biodiversity and environmental values was perceived as an
360 important benefit of planting riparian margins for Group A participants (focal
361 statement 1: *"Riparian margin plantings increase biodiversity values"* and focal
362 statement 5: *"Riparian plantings have benefits for improving water quality"*).
363 Individually, 94% of the 17 Group A participants who responded indicated they either
364 Strongly agreed (65%) or Agreed (29%) with statement 1 (one participant was
365 neutral), and all participants Strongly agreed (41%) or Agreed (59%) with
366 statement 5. Group B's lower level of agreement with the statement *"Riparian margin*
367 *plantings increase biodiversity values"* is not unanimous but is significantly different
368 ($p=0.0058$) to Group A's high level of agreement with the statement. Notably, none of
369 the matters raised by Group B when considering the pros and cons of riparian margin
370 plantings covered biodiversity values. The participants of Group B were, however,

371 more concerned about water quality and felt strongly that while excluding stock from
372 waterways had merit, planting riparian margins did not contribute further to meeting
373 water quality objectives. There was also a sentiment expressed by Group B that
374 Taranaki's water quality was of a high standard and therefore riparian planting
375 programmes were not only ineffective, particularly in comparison to other practices
376 (*"efficiency of margins vs. tiles and drains"*; *"targeting of point sources"*), but also
377 unnecessary (*"...retain water quality that is already well above the world standard"*).
378
379 Group A identified improved relationships with the council as a positive outcome of
380 planting riparian margins under the Taranaki programme specifically (focal
381 statement 6: "*The riparian planting programme has fostered good relationships*
382 *between farmers and regional councils*"). Twelve percent of Group A participants
383 Strongly agreed with this statement, while 81% Agreed, and 6% were neutral,
384 although the group was explicit this was only in the context of TRC and not other
385 regional councils in New Zealand. Group B did not share the same enthusiasm for
386 improved relationships between farmers and TRC, with 40% Strongly disagreeing
387 with this statement, 20% Disagreeing, 20% neutral, and 20% Agreeing (Figure 2).
388 Group A also acknowledged the ongoing one-on-one engagement with council staff,
389 advice, and assistance as a benefit of, and a motivation for, engaging in the Taranaki
390 programme to implement riparian plantings.
391
392 Both groups felt the costs of riparian margin management fell unfairly on them ("*life-*
393 *stylers have no responsibility"*), while benefits accrued to the wider community
394 (*"benefit to the wider community at cost of farmer with margins"*; "*cost to famers vs.*
395 *community benefits*") creating perceived equity issues.

396

397 3.2 Farmer perceived influence of planted riparian margins on the operation and
398 performance of the farm (Q2)

399 Group A participants identified a wide range of pros and cons of the influence of
400 riparian margin plantings on farm productivity and management of the farm system
401 (Figure 3). While acknowledging that there were cons (and costs) involved with
402 riparian margin planting and long-term management of riparian margins, the Group A
403 participants indicated that these were countered by the benefits that riparian margin
404 plantings contributed to the farm system. Two things were notable in the discussion.
405 First, that many negative aspects could be overcome by best practice implementation
406 and management and were not a consequence of riparian margin plantings *per se* (e.g.
407 facial eczema management or plants causing electric fences to earth). Second, while
408 not all perceived benefits of riparian margin plantings directly influenced
409 productivity, they ultimately did. For example, any labour savings gained by not
410 needing to erect temporary fencing in winter or rescue stock from waterways *"can be*
411 *used to think about feed"* and the ability to attract better quality staff and the
412 improved condition of the herd due to the provision of shelter results in *"more milk in*
413 *the vat"*.

414

415 The loss of effective productive land was identified as a direct and immediate trade-
416 off of excluding production from riparian margins. However, the majority of Group A
417 stated that the ability to improve pasture management and the condition of the herd
418 compensated for this loss and profits were the same or better. Group B also identified
419 the loss of production land as a cost of riparian margin management placing it second
420 in importance (after water quality goals of riparian margin planting programmes being

421 unrealistic and unattainable). However, Group B didn't identify any benefits to farm
422 productivity that riparian margin plantings could bring to their farm systems
423 (Figure 1), thus for these farmers, the loss of production land was an unmitigated cost
424 rather than a trade-off between values.
425
426 In regards practical considerations (Figure 1), both groups recognised the negative
427 association between riparian margin plantings and increased pest and weed issues on-
428 farm (*"maintenance of weeds and pests, costs, impacts on development"*; *"building a*
429 *home for pests we are trying to get rid of"*). However, Group A did acknowledge that
430 the extent of weed issues is related to the type and age of the riparian margin
431 plantings. Responses from the LMO survey confirmed that weed and pest
432 management in relation to riparian margin plantings is a pervasive issue for farmers
433 with riparian margin plantings and a perceived issue for farmers without plantings.
434 The surveyed LMOs reported hearing comments to this effect: Frequently (50%), All
435 the time (38%), or Infrequently (12%), although it was noted that the tolerance for
436 weeds in riparian margin plantings varies between farmers.
437
438 Both groups also identified damage to fences, the blockage of drains and culverts, and
439 damage to infrastructure by plants washed downstream in flood events as negative
440 aspects of riparian margin plantings. The surveyed LMOs reported that the damage
441 caused by washed out plants was raised: All the time (25%), Frequently (25%), or
442 Infrequently (50%). However, the LMOs did note that the likelihood of this being an
443 issue was dependent on where in the catchment the plantings were located, and how
444 established the plantings were, with newer plantings being more susceptible to being
445 washed out. The damage caused to fences by riparian margin plantings was raised:

446 Frequently (50%), Infrequently (25%), or Never (25%) with comments of this nature
447 typically referring to the shorting of electric fences. Group B also reflected that
448 impeded drainage by plants blocking drains resulted in further loss of productivity as
449 the land becomes saturated. Riparian margin plantings not only caused blockages but
450 prevented access to remove plant material and sediment from waterways (*"no access*
451 *to waterway for maintenance"*).
452
453 While Group B considered labour costs would increase as a result of these practical
454 problems caused by riparian margin plantings, Group A, while recognising these
455 factors as negative issues, were more likely to acknowledge they could be overcome
456 by improved implementation of riparian margin management (e.g. allowing enough
457 space between fence lines and stream banks to allow plants to grow and planting more
458 high-flow tolerant plants at the waters-edge).
459
460 Group A had given thought to the integration of the riparian margins into their
461 farming system (Figure 3) and saw only small outstanding cost implications. Ten of
462 the 16 (63%) Group A participants who completed the questionnaire agreed with the
463 following statement *"I think that the on-farm benefits from riparian margins are*
464 *greater than the cost to maintain them"* (questionnaire results). In contrast, planting
465 riparian margins was seen by Group B not just as an unnecessary step that came at a
466 cost (*"loss of productive land"; "labour costs"*), but an intervention that did not add
467 to the structure or value of the farm.
468
469 3.3 Farmer motivations for planting riparian margins (Q3)

In responding to the questionnaire, Group A farmers indicated environmental stewardship responsibilities and perceived on-farm benefits as key motivators for planting riparian margins. All Group A participants agreed with the statement *"I planted riparian margins because I believe I have a responsibility for environmental protection and enhancement"* and 75% agreed with the statement *"I planted riparian margins because I wanted to improve water quality for future generations"* (questionnaire results). Ten of the 16 (63%) Group A participants agreed with the following statements *"I planted riparian margins because I was confident that they would improve the productive performance of my farm"* (questionnaire results).

Group A farmers were also motivated by the non-farming communities perceptions of dairy farming and recognised that riparian margin plantings, as a highly visible feature, provided tangible evidence of farmers being pro-active thus improving the image of dairy farmers ("*riparian margin plantings improve public perceptions of dairy farming*"). Feedback from LMO survey confirmed this motivation, stating farmers will often prioritise plantings visible from the road in order to be "*seen to be doing something*" (LMO survey).

In regards the Taranaki programme specifically, Group A farmers indicated their preference to participate in the voluntary Taranaki programme over the Water Accord with its associated threat of compliance ("*double message from regional council and Fonterra —incentives carrot vs. sticks*"). The group also expressed their perception that voluntary participation now will avoid being subject to regulation in the future ("*participation in programme keeps regulation away*").

4. Discussion

The experience of our participant farmers was that retired grass-strip margins provide a range of private and public benefits. The group of farmers who had planted riparian margins perceived the range of benefits flowing from riparian margins to increase due to the addition of riparian vegetation. These benefits fell across the environmental, ecological, social, and production realms. This was in contrast to the group of farmers who had not planted riparian margins, who perceived that retired grass strip riparian margins were adequate to provide the water quality benefits they and the authorities were interested in. Both groups of participant farmers perceived the pros and cons of riparian margin management across a spectrum of scales (paddock, farm, whole catchment) and beneficiaries (self, neighbours, non-farming community). Our results add production and social values to existing environmental and ecological values that have been associated with riparian margin plantings.

4.1 Benefits and values farmers perceive to be associated with planted riparian margins

Several of the benefits for productivity and managing the farm system of planted riparian margins as identified by our participant farmers can also be delivered by fenced only riparian margins. Fencing creates infrastructure that allows for improved farm design and feed allocation that improves farm performance. For example, improved farm mapping of infrastructure assists with the allocation and utilisation of forage, enables greater precision around inputs and management, and prevents injury or death of both livestock and farm staff.

519 Fenced riparian margins are effective in removing animals from waterways, reducing
520 stream bank erosion, and filtering pollutants (phosphorus and pathogens) transported
521 in overland flow to waterways (Collier et al., 1995; Parkyn et al., 2003). In situations
522 where grassed riparian margins are limited in their capacity to filter nutrients (e.g.
523 such as where the phosphorus retention and buffering capacity of soils is limited (Aye
524 et al., 2006), riparian margin plantings can enhance the functionality of the riparian
525 margin through the uptake of plant available phosphorus. However, the inherent
526 capacity of natural capital stocks to filter and retain nutrients is finite and riparian
527 margins are less effective in reducing the losses of nutrients lost by leaching through
528 the soil profile (e.g. nitrogen in porous soils) than in overland flow processes
529 (Buckley et al., 2012; Muscutt et al., 1993; Parkyn, 2004). When combinations of
530 soils, stocking rates, hydrological flows, and farm performance lend themselves to
531 greater nutrient loss, planted riparian margins are less likely to be successful without
532 further management intervention (Howard-Williams et al., 2010; Quinn et al., 2009;
533 Stockan et al., 2012). Therefore, in areas that experience nutrient (particularly nitrate-
534 nitrogen) issues, riparian margin planting programmes should be part of a bigger
535 initiative focused on sustainability and multifunctionality at the catchment scale based
536 on incremental and transitional nutrient management programmes.
537
538 The addition of multi-tier planting to retired riparian margins combines natural capital
539 stocks (riparian vegetation) with built capital which, despite the limitations outlined
540 above, were perceived to deliver further benefits for the farm system. These benefits
541 include shade and shelter for livestock and potential reductions in evapotranspiration
542 of pastoral species. Further, the combination from different natural capital stocks
543 within riparian margins influences margin utility for both farm performance and

environmental enhancement. However, to achieve benefits as far-reaching as possible riparian margins need to be considered as fully integrated components of the farm system and not as exclusive strips on the farm-edge. Group A participants appear to have made this transition, based on the wider range of impacts and benefits they recognise to be provided by their riparian plantings.

The Taranaki programme explicitly links riparian margin plantings to improved water quality. This suggested causal influence has resonated with our study group, who either believed riparian margin plantings contributed to improved water quality (Group A) or questioned this relationship (Group B). However, it is difficult to untangle the benefits of livestock exclusion from waterways and the stabilisation of stream banks from the capacity of riparian plantings to intercept nutrients and other drivers of change impacting on water quality in the Taranaki Region. For example, currently half of the dairy farms in Taranaki legally discharge pond-treated dairy effluent directly into waterways, although there has been a gradual shift to land-based dairy effluent treatment systems in recent times. Eliminating discharge of treated dairy effluent to water is expected to reduce nitrogen loss by an estimated 20% (TRC 2015b). Concurrently, improvements to municipal wastewater treatment systems have driven measurable improvements for the catchments to which they discharge. The strong conviction of Group A farmers that there is a causal relationship between planted riparian margins and improved water quality may be attributable to messaging regards the benefits of riparian margin plantings, that they conceptualise plantings to occur hand-in-hand with fencing and are thus conflating impacts of stock exclusion from waterways with plantings, or other factors such as pre-existing world-views which we did not test for. We also did not investigate which parameters of water

569 quality (e.g. water clarity, nutrient concentrations, water temperature etc.) farmers
570 perceived riparian margin plantings to enhance.
571
572 It is evident from our study that planting riparian margins generates a number of
573 perceived benefits across a range of values. However, great care needs to be taken in
574 extrapolating perceived benefits to actual benefits where these lie beyond what
575 margins realistically can deliver. Importantly, re-establishing riparian margins is not a
576 panacea for all the environmental challenges confronting agricultural landscapes. This
577 was a critical point for some of the participant farmers who recognised that the
578 objective of protecting water quality was unachievable by planting riparian margins
579 alone (Group B). These farmers felt connecting water quality objectives with planting
580 riparian margins was 'misguided', and this perception obscured recognition of all
581 other potential values and benefits in planting riparian margins and prevented these
582 farmers from implementing plantings within their riparian margins. Lessons can be
583 learnt for engaging farmers in riparian management programmes elsewhere in the
584 country whereby wider uptake may be achieved through both broadening the
585 objectives for riparian margin planting programmes to more adequately reflect the
586 potential for benefits beyond improved water quality, and recognising the inability of
587 planted riparian margins on their own to fully address the national water quality
588 challenge.
589
590 4.2 Farmer identified motivations for planting riparian margins
591 The recent National Policy Statement for Freshwater Management (Ministry for the
592 Environment, 2014) has given greater urgency to nutrient management. As a
593 consequence, greater regulatory intervention nationally for nutrient management in

some form is on the horizon. Although Taranaki does not experience nutrient loss issues of the same magnitude as elsewhere in New Zealand due to the high, frequent rainfall and short, fast stream flows, combined with good soils and a long history of dairy farming with relatively low stocking rates (TRC, 2015), participant farmers possess a well-tuned awareness of national water quality issues. Despite TRC operating a non-regulated approach to nitrogen management, participant farmers expressed anticipation of increased regulation on-farm to combat declining water quality in agricultural catchments. Taranaki Regional Council were proactive in creating the Taranaki Programme, being the first council in New Zealand to implement a riparian margin planting programme and pre-dating industry-driven programmes to exclude stock from waterways. Under the Taranaki Programme, a large number of riparian plans were developed well before water quality became especially topical in the public conversation nationally. However, in more recent times, the 'threat' of future regulatory action may have increased the appeal of the Taranaki programme. In partaking in the voluntary Taranaki programme, farmers are anticipating impending nationally-led regulation and pre-empting future obligations.

A further benefit of planting riparian margins expressed by Group A participants was improving non-farmer perceptions of dairy farming. Farmers are increasingly conscious of the wider community's perception of them as individuals and of their industry as a whole which has attracted the unenviable label of 'dirty dairying'. The public's perception of farming and reduced tolerance for land use induced environmental degradation is likely to be providing a concurrent motivation for farmers that haven't already done so to voluntarily plant riparian margins on their farms. Fenced and planted riparian margins are highly visible features in the

619 landscape and thus send a tangible message to the non-farming community that good
620 land use practices are being implemented.
621
622 The continued trends of native biodiversity decline (Ministry for the Environment and
623 Statistics New Zealand, 2015), suggest that enhancing biodiversity values is not
624 perceived to be beneficial enough on-farm to be a sufficient motivator for farmers to
625 engage in riparian margin planting, or perceived to be a beneficial outcome of doing
626 so. Contradicting this assumption, Group A perceived a causal relationship between
627 riparian margin plantings and increased biodiversity values (in particular bees, birds,
628 and frogs). However, the definition of 'biodiversity' (and therefore the associated
629 values) referred to by our study group is not restricted to native biodiversity or that
630 required to achieve conservation objectives. The planted riparian margins are not
631 providing complete ecological equivalents for lost native habitat, and where they
632 differ in species assemblage, are unlikely to be in the future. Thus, while Group A
633 farmers perceive biodiversity benefits to flow from planted riparian margins these
634 benefits are not analogous with biodiversity conservation benefits. Rather, a wider
635 view of biodiversity is reflected relating to, for example, greater structural diversity,
636 benefit of biodiversity for production values, and amenity values associated with
637 diversity in the landscape. This illustrates an encouraging step towards integrating
638 riparian margins into the farm system in its entirety, although conservation challenges
639 are likely to persist.
640
641 Both groups of participant farmers expressed a preference for a non-regulatory
642 approach to riparian margin management. In the absence of compulsion, the voluntary
643 motivation to undertake specific actions requires not just an attitude change but also a

644 behaviour change (Rhodes et al., 2002). When left entirely to voluntary mechanisms
645 this shift in behaviour (adoption of action) is based on subjective rather than objective
646 decision making and can be very slow (Pannell et al., 2006). This can be problematic
647 in situations where riparian margin management is being used in response to urgent
648 resource issues.
649
650 A switch in focus from riparian margins sitting outside the farm system to riparian
651 margins being integrated into the farm system would likely expedite their adoption by
652 demonstrably providing a suite of services and benefits. If retired and planted riparian
653 margins can be shown to have a relative advantage over fenced-only or farmed
654 riparian margins the practice will likely become more economically and socially
655 appealing. Land management practices that have a relative advantage over alternative
656 actions are more likely to be adopted (Pannell et al., 2006). Further, effective
657 voluntary schemes require effort, commitment and clear expectations from both the
658 implementing agency and land owner. Ultimately, voluntary schemes should be time-
659 bound and replaced with regulation to capture the minority of land owners who
660 choose not to partake voluntarily. When these aspects are in place, uptake is likely to
661 be more rapid and implemented by more landowners. The Taranaki Programme
662 illustrates this well, where sustained support and encouragement from TRC over the
663 past 20 years has resulted in large-scale uptake of the programme (c.99.5% of dairy
664 farmers on the ring plain now have a riparian planting plan in place, TRC *pers com*),
665 while those farmers who have not yet planted their riparian margins will in the future
666 be obliged to do so under proposed rules in the Regional Freshwater Plan (RFWP).
667

668 Many studies have recognised the value of riparian margin management for
669 ecological or environmental benefits (e.g. Bennett et al., 2014; McCracken et al.,
670 2012; Wilcock et al., 2009). Other studies take a more productivist view and
671 recognise the values to the farm system that riparian margin habitat can provide, such
672 as provision of habitat for pollinators and fauna beneficial for pest control or potential
673 benefits of native vegetation for animal nutrition (Cole et al., 2015; Hahner et al.,
674 2014; Wratten et al., 2012). Our study brings productivist, ecological, environmental,
675 and social values together, providing a broader foundation of information that is
676 useful for refining future policy. Further quantification and qualification of the raft of
677 values provided on and off-farm by planted riparian margins is required to identify
678 and incentivise riparian margin management that best supports multifunctional farm
679 systems.
680
681 **5. Conclusions**
682 Our findings show that farmers who had not yet planted riparian margins were
683 reluctant to do so because they were not convinced that planted multi-tier riparian
684 margins provided additional gain over fenced grass strip riparian margins for the
685 purposes of improving water quality and they did not perceive any additional benefits
686 from riparian plantings. In contrast, farmers with planted margins perceive the
687 introduction of vegetation natural capital stocks into riparian margins to provide many
688 benefits and have started to recognise and value the environmental, production, and
689 social functions of riparian margins in an integrated way.
690
691 The reinstatement of native vegetation within riparian margins in highly modified
692 landscapes like the Taranaki ring plain, creates novel ecosystems, the establishment of

693 which can generate social, environmental, biodiversity, and functional benefits.
694 Strengthening multifunctional agriculture is not only positive for the farm system but
695 can resonate with the non-farming community who see this as a preferable model for
696 farming (Wilson, 2008). However, the management of riparian margins is not a
697 panacea for all land management issues and the practice does necessitate trade-offs.
698 We suggest that multi-tiered riparian margins can become an integral part of the farm
699 system and can contribute to multifunctional landscapes. However, the planting of
700 riparian margins needs to sit within a more comprehensive policy framework
701 providing incremental mitigation options if a wider range of negative externalities
702 generated by land use practices are to be reduced.
703
704 **Ethical Clearance**
705 This study adheres to the Guidelines of the ethical review process of The University
706 of Queensland and the National Statement on Ethical Conduct in Human Research.
707 Approval number: 2015000319.
708
709 **Conflict of interest**
710 The authors confirm that there is no conflict of interest with the organisations or any
711 other aspect of the content of this paper.
712
713 **Acknowledgements**
714 The authors would like to thank the dairy farmers of Taranaki who generously
715 donated their time to participate in this study, and the Taranaki Regional Council
716 Land Management Officers, in particular Don Shearman, who helped facilitate
717 participation. We are grateful to Taranaki Regional Council and AgResearch for

718 financial and in-kind support, and the New Zealand Ministry of Business, Innovation
719 and Employment funded research partnership project BEST (Building biodiversity
720 into an ecosystem service-based approach for resource management) for additional
721 funding. FM is funded by an ARC Australian Postgraduate Award, an ARC Centre of
722 Excellence for Environmental Decisions Top Up Scholarship, and also received
723 funding from BEST for this project. For comments that improved the manuscript we
724 thank Vanessa Adams, Peter Taylor, Hugh Possingham, Yvonne Buckley, Don
725 Shearman, Gary Bedford, and Stephen Hall. Figure 3 created by Michelle Baker,
726 adapted from Taranaki Regional Council riparian planting programme support
727 material (http://www.trc.govt.nz/riparian-management/).
728

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859

Table 1: The nine categories summarising farmer perceived pros and cons of planted riparian margins.

Category		Themes captured
A. Environmental		
1	Environmental	Environmental responsibility; environmental enhancement
B. Social		
2	Social responsibility	Personal values; relationships; perceptions of the non-farming community
3	Equity	Distribution of costs and benefits between farmers and non-farming community; differing requirements between farms
4	Community-scale benefits	Benefits to local economy; benefits to local community
5	Aesthetics	Visual amenity
C. Financial		
6	Financial	Farm productivity; direct on-farm costs and savings
D. On-farm management		
7	Practical considerations	Practicalities of establishing and maintaining riparian margin plantings; interaction with wider farm management
8	Welfare	Safety of personal; safety and welfare of stock
E. Taranaki programme specific		
9	Programme design	Programme requirements; priorities; programme implementation; supporting policies; messaging

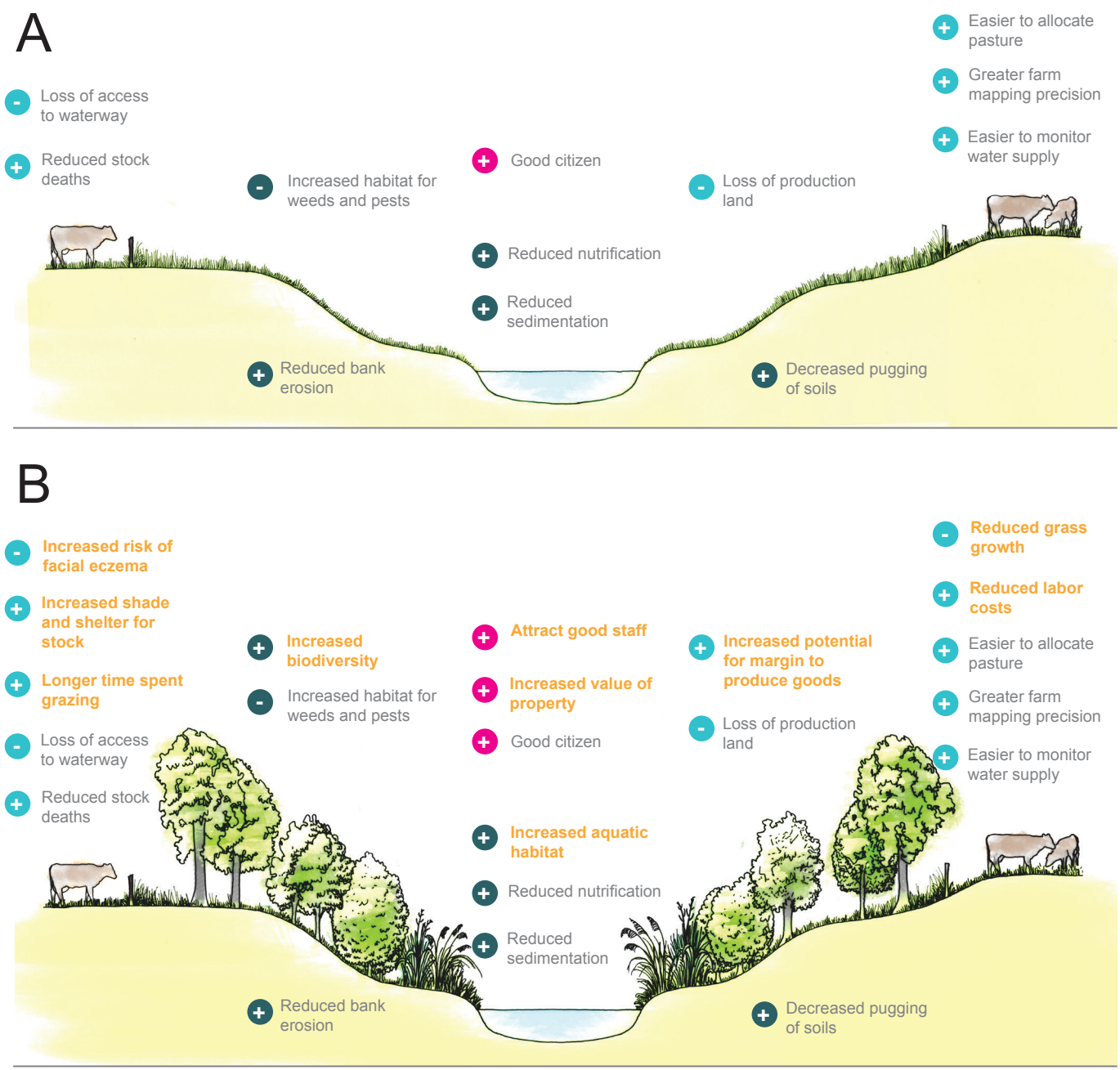
Table 2: The ten focal statements describing aspects of planted riparian margins. The statements were transposed from the top ten aspects of riparian margin plantings of most relevance to Group A (voted by Group A from a group-generated list of 32 pros and cons). The category (Table 1) that each statement falls within is shown in the fourth column.

Rank	Theme	Statement	Category
1	Biodiversity	Riparian margin plantings increase biodiversity value	1
2	Stock management	Riparian margin plantings assist in stock management (avoided losses)	6
3	Pasture management	Riparian fencing helps with pasture management	7
4	Shade & shelter	Riparian plantings provide multiple functions (shade and shelter for stock)	8
5	Water quality	Riparian plantings have benefits for improving water quality	1
6	Council-farmer relationship	The riparian planting programme has fostered good relationships between farmers and regional council	2
7	Costs	Different farms are subjected to different costs with riparian plantings	3
8	Farm management	Riparian plantings make you think about management in a broader way	7
9	Weeds & pests	There are ongoing weed and pest maintenance costs from riparian plantings	7
10	Public perceptions	Riparian plantings improve public perceptions of dairy farming	2

868 **Figure legends**

869 **Figure 1:** Aspects of planted riparian margins by category showing the percentage of
870 pros (upper hollow bars) and cons (lower striped bars) generated by farmers.
871 Categories are grouped by type: A = Environmental; B = Social; C = Financial; D =
872 On-farm management; E = Taranaki programme specific. Group A (Planters)
873 identified a total of 21 (66%) positive aspects across eight categories (hollow purple
874 bars); and 11 (34%) negative aspects across four categories (purple vertical striped
875 bars); Group B (Non-planters) identified zero positive aspects and 15 (100%) negative
876 aspects across four categories (green vertical striped bars).
877
878 **Figure 2:** Farmer agreement with the ten focal statements generated by Group A
879 describing aspects of riparian margin plantings. Level of agreement was measured
880 using a five-option Likert scale (y-axis). Blue triangles denote Group A responses,
881 mean values indicated by blue horizontal bars. Grey crosses denote Group B
882 responses, mean values indicated by grey horizontal bars. A significant difference in
883 level of agreement (95% confidence level) between the two groups was detected for
884 five statements (1, 4, 5, 8, and 9) as indicated by an asterisk (*).
885
886 **Figure 3:** Schematic of pros and cons of retired single-tier grass strip riparian margins
887 (Panel A) and retired multi-tier planted riparian margins (Panel B) as identified by
888 dairy farmers farming the Taranaki ring plain (n = 23). *Stock exclusion from*
889 *waterways* avoided livestock deaths of 2% of the herd/year, saving $2,000/cow;
890 $50/calf and 2 hr labour/day. Fencing costs $5/m ($1–$15/m depending on fence type
891 and topology, authors figures). *Reduction of production land* can range between 5–
892 15% and leads to the reduction of stock numbers. The loss of grass due to retirement

893 of riparian margins may require the use of supplementary feed. *Greater farm mapping*
894 *precision* allows for better allocation of feed and greater paddock selection for
895 rotational grazing. Better utilisation of grass can deliver the same or better profit and
896 if grazing riparian margins. *Better management water supply* avoids stock illness and
897 death due to liver fluke ($2,000/cow). *Planting of riparian margins* costs $5/m (or
898 ranges from $10–$30/m for 5 m wide multi-tiered planting, authors figures) and
899 requires ongoing maintenance. *Labour costs* are reduced by not having to care for sick
900 animals or dispose of dead animals (2 hr/ day). Permanent fencing removes the need
901 to erect temporary fences around drains and waterways during winter (1–2 hr/day).
902 *Value of property* is increased as a fully fenced and planted farm is more attractive to
903 buyers as they save on fencing and planting costs. Planted riparian margins have the
904 potential to produce goods (e.g. firewood, stock fodder, crop trees) but are required to
905 be greater than 20 m wide to gain carbon credits. Individual attributes of riparian
906 margins can contribute values across the spectrum, for example, a well managed farm
907 attracts better staff which is shown here as a social value, but also ultimately
908 contributes to great productivity of the farm (a production value). All figures and
909 trade-offs supplied by participant farmers from Group A or supplemented by the
910 authors as indicated. Dollars are given in New Zealand dollars (NZ$100 = USD$75
911 on 14 May 2015).



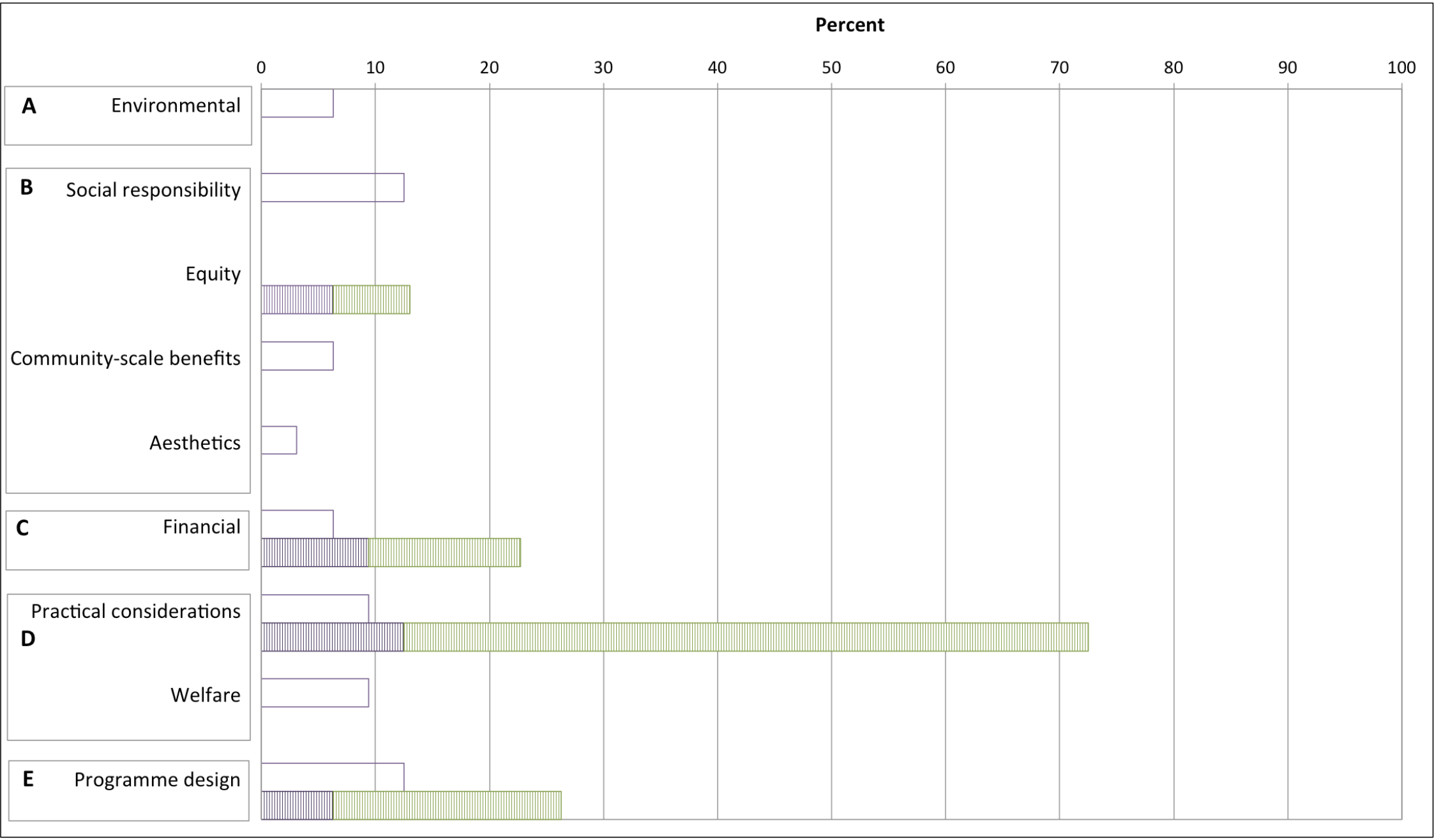
KEY

Type of impact:

- (+) Positive
- (-) Negative

Values:

- Production
- Environmental
- Social


Percent
0
10
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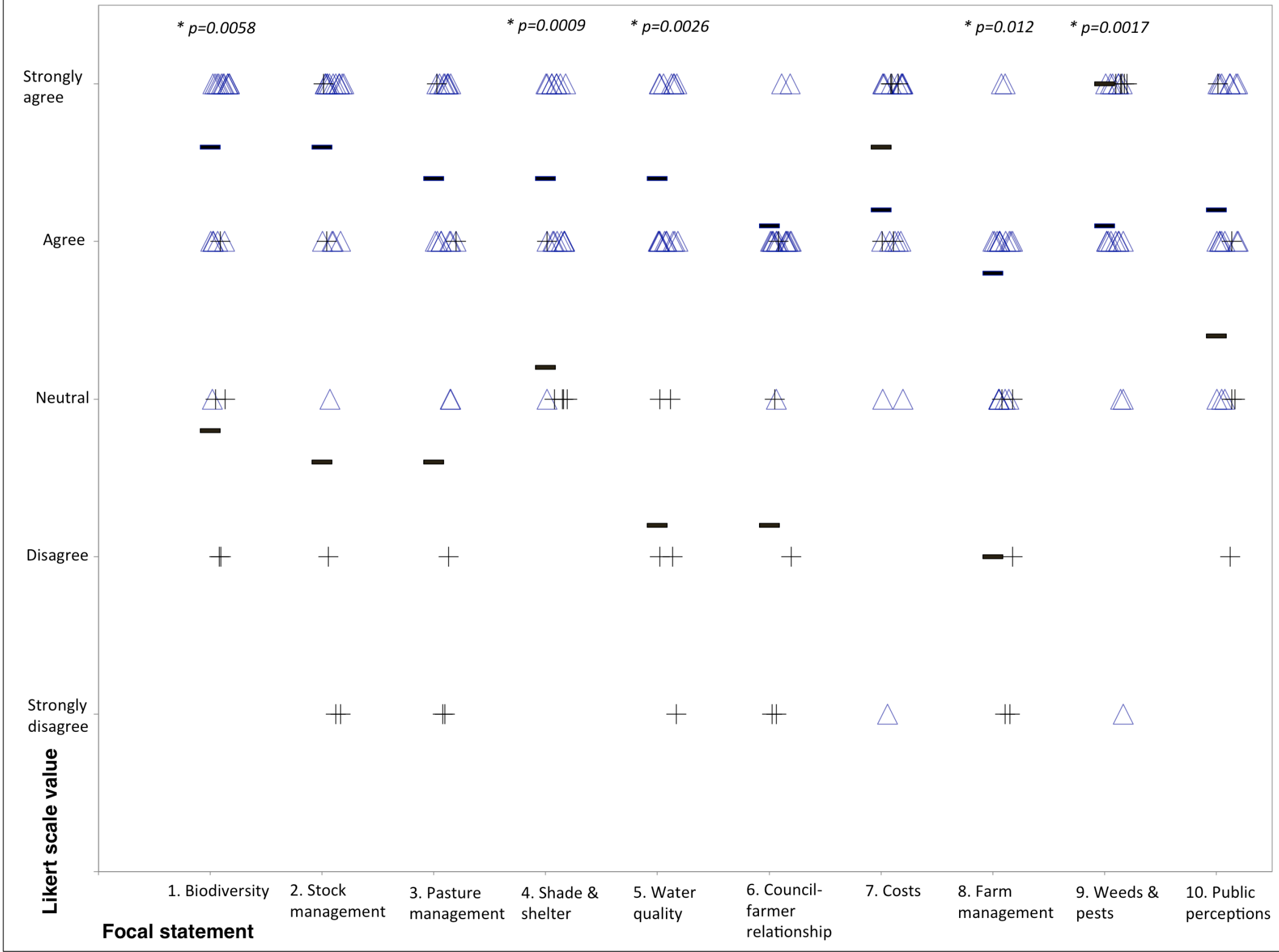
A
Environmental
B
Social responsibility
Equity
Community-scale benefits
Aesthetics
C
Financial
Practical considerations
D
Welfare
E
Programme design


* p=0.0058
* p=0.0009
* p=0.0026
* p=0.012
* p=0.0017
Strongly agree
Agree
Neutral
Disagree
Strongly disagree
Likert scale value
1. Biodiversity
2. Stock management
3. Pasture management
4. Shade & shelter
5. Water quality
6. Council-farmer relationship
7. Costs
8. Farm management
9. Weeds & pests
10. Public perceptions
Focal statement