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RESEARCH

# Understanding farmer behaviour: A psychological approach to encouraging pro-biodiversity actions on-farm

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**Abstract:** Understanding farmer behaviour and drivers for behaviour change will be the key to bringing about practice change, such as increasing management and enhancement of native biodiversity on-farm. Farmer participation in biodiversity protection and management is a critical challenge for both national conservation outcomes and achieving more sustainable farm systems. Enhancing native biodiversity provides a mechanism for increasing the sustainability of food and fibre production, mitigation of environmental emissions, and enhancing the resilience of farm systems to weather events and the impacts of climate change. We surveyed 500 sheep and beef farmers throughout New Zealand using a survey explicitly based on the dominant psychological model of volitional behaviour, the Theory of Planned Behaviour (TPB). Farmers' attitudes, perception of social norms, control beliefs, moral obligation, and perceived private-public benefit, regarding the protection and management of native biodiversity on-farm, were investigated. We used a combination of descriptive statistics, correlation analyses, and TPB regression modelling of the survey data to understand past pro-biodiversity behaviour and future intentions to implement pro-biodiversity behaviours on-farm. We found that sheep and beef farmers saw (1) greater public than private benefit resulting from the protection and management of native biodiversity on-farm; (2) belief in the efficacy of specific biodiversity behaviours has a stronger relationship with actual behaviour than intentional behaviour; and (3) planning for pro-biodiversity behaviours, such as in a farm planning process, increases farmer pro-biodiversity behaviour. We conclude there is a need to increase farmer understanding of pro-biodiversity practices and outcomes for both farmer private and public benefit and the removal and dissolution of perceived barriers and constraints preventing more pro-biodiversity behaviour on-farm. Based on this research, we recommend that policy initiatives should be targeted at (1) illustrating and communicating the multiple values of native biodiversity to farm systems and farming enterprises (private benefit), and to ecosystem function and New Zealand's conservation objectives as a whole (public benefit); (2) the specific areas operating as behavioural controls on pro-biodiversity behaviour, and (3) integrating native biodiversity considerations into farm planning processes.

**Keywords:** behaviour change, policy interventions, pro-biodiversity behaviour, public-private benefit, theory of planned behaviour

## Introduction

The need to increase and enhance native biodiversity on-farm for many purposes is increasingly being acknowledged. For example, as a tool by which to increase resilience on-farm and the potential for emission and climate change mitigation (Dominati et al. 2019; Maseyk et al. 2019), to reverse the drawdown of natural capital stocks associated with the production of food and fibre, and to address New Zealand's biodiversity crisis (Bradshaw et al. 2010; Brown et al. 2015). As a result, there are an increasing number of policies and initiatives targeted at enhancing biodiversity on-farm and throughout New Zealand. Some farmers are also already undertaking measures to protect biodiversity on their farms. While these actions are positive, there remains a clear need to incentivise and support both the extent and rate at which pro-biodiversity actions are implemented on-farm (Pannell 2008). Increased understanding of farmer behaviour and behaviour change is key to effectively targeting such policy incentives.

### The attitude-behaviour gap

Although general attitudes can predict general actions or wider goals, general attitudes are poor predictors of specific behaviours (Fishbein & Ajzen 1974). In contrast, attitude towards a specific behaviour is a good predictor of that specific behaviour. Ajzen and Fishbein (2005) refer to this phenomenon as "the principle of compatibility"; the attitude predictors and the behaviour criterion variables must be at the same level of specificity or generality. However, while general attitude is a poor predictor of specific behaviour, it may be a

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good predictor of an aggregated set of behaviours that represent the construct domain of interest. Ajzen and Fishbein (2005) refer to this phenomenon as "the principle of aggregation".

These two principles are important in the design of the current study, which has two independent (although related) criterion variables that were collected concurrently in a phone survey of 500 New Zealand sheep and beef farmers: (1) Farmers' behavioural intention to manage and protect New Zealand's native biodiversity (a general behaviour or goal), and, (2) farmers' past and current native biodiversity behaviour (hereafter past biodiversity behaviour), measured as an aggregate score of ten selected biodiversity behaviours believed to represent the construct domain of biodiversity management and protection. Thus, prediction of the behavioural intention criterion complies with the principle of compatibility and the prediction of the past behaviour criterion complies with the principle of aggregation.

### The Theory of Planned behaviour (TPB)

The TPB holds that the most immediate determinant of behaviour is intention: the stronger the intention, the more likely the behaviour is to occur. Because of the strong relationship between intention and specific behaviours, intentions have become a major component of several social behaviour theories. Ajzen and Fishbein (2005) claim that, although these theories differ in detail, there is convergence on three main antecedent variables explaining intention. These are the three main explanatory variables in the TPB: attitude towards the specific behaviour (i.e. beliefs about the likely positive or negative consequences of the behaviour), subjective norms regarding the behaviour (i.e. the perceived social pressure from respected individuals or groups to perform or not to perform the behaviour), and perceived behavioural control (the perception of the actor about their ability, and lack of other constraints, to perform the behaviour) (Fig. 1). Demographic, situational, and structural factors that also influence farmer biodiversity behaviour are postulated by the TPB to be more distal predictors and to function through the TPB theory variables of behavioural beliefs, normative beliefs, and control beliefs.

The TPB is an adaptation of the earlier theory of reasoned action (TRA; Fishbein & Jaccard 1973; Ajzen & Fishbein 1977) and differs from the earlier theory primarily by its recognition of the influence of control beliefs on subsequent behaviour. Many studies have used both the TRA and TPB to predict behaviour across a wide range of behaviour domains, with intention consistently being found to be a good predictor of behaviour (Ajzen & Fishbein 2005). Meta-analyses of the TRA and TPB literature have shown that measures of attitude to the behaviour, subjective norms, and perceived behavioural control can accurately predict behavioural intention (Godin & Kok 1996; Sheeran & Taylor 1999; Armitage & Conner 2001; Hagger et al. 2002).

Predicting the future is complex, and the TPB is not a theory of attitude change. However, the theory has become the dominant social psychology model for explaining volitional human behaviour (Fishbein 2015) and can provide valuable insights as to where to target policy interventions or tailor support to help influence behaviour change in desired directions. Thus, and due to the wide empirical support for the validity of the TPB for explaining pro-biodiversity behaviour (Kilbourne & Pickett 2008; Sidique et al. 2010), we consider that the TPB provides a justifiable construct to underpin this study.

Therefore, we explicitly designed a phone survey based on the three proximal behavioural intention predictor variables of

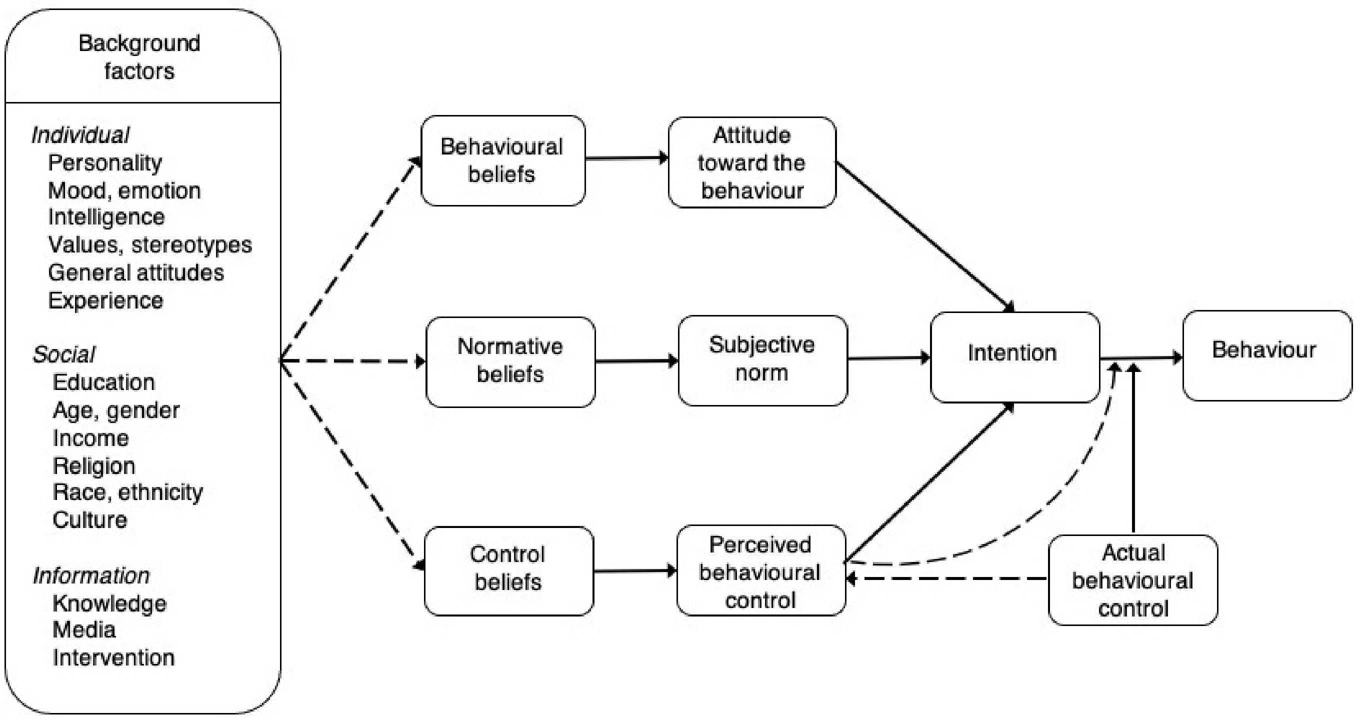


**Figure 1.** The theories of reasoned action and planned behaviour (adapted from Ajzen & Fishbein 2005, p. 194) showing relationship between beliefs, attitudes, intentions and behaviour. Beliefs are influenced by background factors (left of diagram). The theory conceptualises that a person's intention is the most proximal influence on their subsequent behaviour, assuming the person has control over that behaviour. For simplicity, the arrows showing the relationship between attitude, subjective norms, and perceived behavioural control are not displayed in the above diagram.

the TPB and additional constructs: moral behaviour based on Rest's theory of moral obligation (Rest 1986) and the private-public benefits framework (Pannell 2008). The survey explored the attitudes, perceived social norms, and perceived control beliefs regarding the protection and management of native biodiversity on-farm of sheep and beef farmers throughout New Zealand.

We employ descriptive statistics, correlation analyses and TPB regression modelling of the survey data to understand both past pro-biodiversity behaviour and future intentions to implement pro-biodiversity behaviours on-farm. These findings are used to identify potential areas to target policy initiatives aimed at improving uptake of pro-biodiversity practices on-farm and opportunities to remove behavioural controls and barriers preventing farmers from acting on their good intentions.

**Data collection**

A phone survey of sheep and beef farmers was designed based on TPB and included questions targeted at eliciting responses relating to:
(1) Farmers' understanding of native biodiversity,
(2) beliefs about specified land management practices and outcomes of these practices,
(3) past and current behaviour in regard to specified land management practices,
(4) beliefs about barriers to undertaking pro-biodiversity land management practices.

The survey was conducted between March and April 2019 by UMR Research. Survey participants were recruited from Beef+Lamb New Zealand's database. Farmers who self-identified as having areas of native bush/flora or habitat on their farm were screened into the survey until a total of 500 farmers had participated. The survey sample was stratified across Beef+Lamb New Zealand's seven operational regions replicating the distribution of farmers with areas of native bush, flora, wetlands, or tussock in each of these regions.

The survey comprised a total of 12 research questions with additional questions relating to the characteristics of the farm and the demographics of the respondents. In this paper, we focus on the sections of the survey that explored: (1) Farmers' understanding, attitudes, subjective norms, perceived behaviour control and behavioural intention in the context of managing and protecting biodiversity on their farm, (2) outcome evaluation of the efficacy of specific on-farm practices for the protection and management of native biodiversity, and (3) including pro-biodiversity actions in a farm environment plan (see Maseyk et al. 2021a for additional analysis of the survey data).

**Measuring independent predictor variables and behavioural intention criterion**

Respondents were asked to express how strongly they agreed or disagreed with seven statements using a five-point Likert Scale that was anchored at each end (1 = strongly disagree and 5 = strongly agree) with the midpoint (3) assumed to be neutral. The seven statements were designed to examine the attitudes and beliefs that proponents of the TPB describe as key components in understanding behaviour (Fig. 1), plus our additional constructs:
(1) Managing and protecting biodiversity on your farm is very important to you (attitude to biodiversity behaviour),
(2) you feel a moral duty to manage and protect native biodiversity on your farm (moral obligation),
(3) managing and protecting native biodiversity on your farm helps enhance New Zealand's native biodiversity (behaviour belief/outcome evaluation of public benefit),
(4) managing and protecting native biodiversity on your farm improves your farm system (behaviour belief/outcome evaluation of private benefit),
(5) most people who are important to you believe that you should manage and protect native biodiversity on your farm (perceived social norm),
(6) you have the necessary skills and resources to manage and protect native biodiversity on your farm (perceived behavioural control),
(7) you intend to continue, or in the near future start, managing and protecting native biodiversity on our farm (behavioural intention).

The behavioural belief statements (3) and (4) above are based on Pannell's (2008) public benefits, private benefits framework. This distinction is consistent with Schwartz's (1992) structure of human values which identifies a clear conceptual path from higher-order value dimensions of self-enhancement, and its opposite, self-transcendence, to an individual's preferred balance of private-public benefit. The further self-rated knowledge question "How much would you say you understand what the term "native biodiversity" means?" was asked of survey respondents using a 5-point scale (1 = do not understand at all and 5 = completely understand). All questions also gave the option to express uncertainty via an 'unsure' response. As the impact of the unsure responses on the data was negligible, these responses were removed from statistical analysis (treated as missing data).

**Measuring outcome evaluation of the efficacy of ten specific biodiversity behaviours**

To determine their behavioural beliefs (evaluative consequences of the behaviour), farmers were asked to indicate (yes, no, unsure) which actions on a list of on-farm practices designed to represent the pro-biodiversity construct domain they considered "help to protect and manage New Zealand's native biodiversity as a whole?" The list presented to survey respondents is by no means an exhaustive list of pro-biodiversity behaviours but was designed to reflect common practices typically targeted by initiatives to enhance native biodiversity. In compiling the list, consideration was also given to the likelihood the actions would be familiar to farmers. The list consists of the following ten actions:
(1) Fencing of bush blocks and/or gully vegetation to permanently exclude livestock,
(2) fencing of wetlands and/or waterways to permanently exclude livestock,
(3) permanently excluding livestock from areas of the farm (such as hill slopes) and allowing these areas to revert naturally,
(4) legally protecting such as putting an area under a QEII covenant,
(5) planting native species in riparian zones,
(6) planting of native species such as to buffer a bush block, or in a gully, or to create new habitat such as a wetland,
(7) regularly controlling (poisoning, trapping, shooting) possums,
(8) regularly controlling (poisoning, trapping, shooting) feral herbivores such as goats, pigs, and deer,
(9) regularly controlling (poisoning, trapping, shooting) animal pests such as mustelids, feral cats, rats, and wasps,
(10) undertaking weed control, other than pasture weeds.

### Measuring past biodiversity behaviour criterion

Survey respondents were then asked which of these ten practices they were "doing or have done to manage and protect your own farm's native biodiversity?" The response set was: yes, no and unsure.

### Testing the benefits of including actions to improve biodiversity in farm planning processes

The gap between intention and behaviour is reduced as the issue becomes more relevant to the actor and as actor involvement increases (Ajzen & Fishbein 2005). The gap may also be reduced by asking the actor to form an implementation intention; specifying when, where, and how they will carry out their behavioural intention (Gollwitzer 1999; Sheeran & Orbell 1999). Similarly, goal-setting behaviour has been shown to increase performance (Locke & Latham 2006). Specifying farm-specific pro-biodiversity behaviours in farm planning, makes the behaviour more relevant to the farmer, increasing their involvement. Further, a plan which includes what, where, when, and how of a specific action is an expression of an implementation intention. Therefore, our alternate hypothesis is that the inclusion of actions to improve biodiversity in farm planning processes enhances farmer pro-biodiversity behaviour. This alternative hypothesis was informed by the survey questions asking respondents if they "had a farm environment plan" and if they "had included actions to improve biodiversity in their farm plan."

### Data analysis

*Behavioural belief and past behaviour scores*

To use the behavioural belief variable in the model, a 10-point aggregate score was constructed for each farmer by tallying the number of on-farm practices that they considered to be effective in protecting and managing biodiversity (from the total of 10 listed practices). The same approach was taken to construct a 10-point aggregate score for the past behaviour variable using the number of listed practices they had implemented or were currently practising on-farm. Lower scores represent a lack of belief in the outcome efficacy of the specified on-farm practices and lower implementation of these practices, respectively (Table 1).

*Descriptive statistics*

Likert scale results were expressed as frequency and percentage of surveyed farmers who placed themselves at each point on the scale. Mean score, standard error, and standard deviation were calculated for each independent and dependent variable. Unsure responses were removed from the dataset and treated as missing variables for the statistical analysis. The same descriptive statistics were calculated for both 10-point constructed scores (Table 2).

*Correlations between predictors and criteria*

We used correlation analyses to assess the relationship between the TPB predictor variables and behavioural intention (the intention to continue, or in the near future, start managing and protecting biodiversity on-farm) and past behaviour (past and current pro-biodiversity behaviours on-farm). This analysis helps determine the predictor variables with the most influence on our two criteria (dependent) variables, behavioural intention and past behaviour.

Our alternate hypotheses are that each of our predictor variables will be positively related to each of the criterion variables (a total of 16 hypotheses). We also make a 17th alternate hypothesis, suggested from previous research (Ajzen & Fishbein 2005), that past behaviour will be positively related to behavioural intention. As all our hypotheses were directional, one-tailed significance tests were used. To control for family-wise error rate (FWER) associated with multiple hypothesis tests, the stringent Bonferroni correction was applied to adjust the Type I error rate (Vickerstaff et al. 2019). The Bonferroni corrected alpha value for significance is thus set at $.05/17 = p < 0.003$. Note all correlation $p$-values reported in the text and tables are uncorrected, observed values.

In the behavioural sciences the conventions for the magnitude of the correlation effect size are: 0.1 = a small effect size; 0.3 = a medium effect size; and 0.5 = a large effect size (Cohen 1988). With a sample size of 500, the statistical power to detect even a small correlation effect of 0.1 is 0.61, while the power to detect a medium correlation of 0.3 and above is effectively 1.0.

**Table 1.** Percent of farmers who believe each on-farm practice is efficacious compared with percent of farmers who are or have implementing the same practice on their farm.

| On-farm practice | Believe specified behaviour is efficacious | Are or have carried out the specified behaviour | Percentage difference |
|---|---|---|---|
| Regularly controlling possums | 98.4 | 92.2 | 6.2 |
| Regularly controlling animal pests | 96.4 | 81.6 | 14.8 |
| Regularly controlling feral herbivores | 94.8 | 71.4 | 23.4 |
| Undertaking weed control | 91.8 | 89.6 | 2.2 |
| Fencing of bush blocks/gully vegetation | 89.4 | 72.8 | 16.6 |
| Planting of native species in a bush block, or in a gully, or to create new habitat | 89.4 | 48.8 | 40.6 |
| Planting native species in riparian zones | 88.4 | 54.4 | 34 |
| Fencing of wetlands/waterways | 87.0 | 76.0 | 11 |
| Legally protecting | 79.0 | 27.0 | 52 |
| Permanently excluding livestock and allowing areas to naturally revert | 69.0 | 49.8 | 19.2 |

**Table 2.** Descriptive statistics for all TPB variables. Means are based on a 5-point Likert Scale for all variables (higher score = greater agreement) except for variables indicated with an asterisk (*) where the mean is based on a 10-point constructed scale. All 'unsure' responses were removed from the data and treated as missing variables in the statistical analysis.

| TPB variables | *n* | Mean | SE | StDev |
|---|---|---|---|---|
| *Independent variables* | | | | |
| Understanding of biodiversity | 492 | 3.64 | 0.052 | 1.16 |
| Attitude to behaviour | 499 | 4.20 | 0.042 | 0.95 |
| Moral obligation | 500 | 4.23 | 0.042 | 0.93 |
| Evaluative beliefs – public benefit | 495 | 4.34 | 0.041 | 0.91 |
| Evaluative beliefs — private benefit | 496 | 3.40 | 0.054 | 1.20 |
| Perceived social norm | 486 | 3.89 | 0.049 | 1.09 |
| Perceived behavioural control | 495 | 3.75 | 0.047 | 1.05 |
| Behavioural beliefs (efficacy)* | 500 | 8.84 | 0.074 | 1.65 |
| *Dependent variables* | | | | |
| Behavioural intention | 495 | 4.15 | 0.045 | 1.01 |
| Past biodiversity behaviour* | 500 | 6.63 | 0.088 | 1.96 |

*The influence of including actions to improve biodiversity included in farm planning processes*

A one-tailed independent-samples *t*-test was conducted to test the alternate hypothesis that including actions to improve biodiversity in farm planning ($n$ = 204) increases farmer biodiversity behaviour over having no farm plan ($n$ = 243), or a farm plan without actions to improve biodiversity included ($n$ = 53). For this test, the "no farm plan" and "farm plan but no biodiversity actions" were grouped together giving a total $n$ = 296.

*Modelling behavioural intention and past behaviour*

Because the TPB has multiple predictor variables (and we included additional ones), we also conducted regression analyses on both independent variables. Multiple predictors can improve the variance explained over the best single predictor. An iterative process was used to determine the most parsimonious model for the two criteria. The same process was used for both criteria (intention and past behaviour).

A best subsets analysis was run using the full set of independent variables to identify likely models (Olejnik et al. 2000). As a confirmatory exercise, an alternative approach to determining the appropriate model (stepwise regression), using forward selection, was conducted with 10-fold cross-validation (Rooij & Weeda 2020). The validation procedure helps to reduce model overfit and test the model's utility to predict new data that were not used in estimating the model. Finally, regression analyses were conducted on subsets from these two processes, with the best models being identified by fit with the indices $R^2$ (adj), $R^2$ (pred) Mallows CP, AICc and BIC. Our alternative hypotheses are: regression analyses using a subset of the eight predictor variables explains a significant proportion of the variance in the two criterion variables (two hypotheses).

## Results

### Farmer understanding of native biodiversity

The surveyed farmers expressed a moderate level of confidence in their understanding of the term "native biodiversity" ($\bar{x}$ = 3.64) with over half placing themselves as a 5 (completely understand: 26.2%) or a 4 (31.8%). Only eight farmers (1.6%) were unsure, although over a quarter (25.8%) were neutral (3 on the response scale). Note, however, the low correlation $r(498) = 0.12$, $p = 0.007$, a non-significant result with the Bonferroni correction applied between self-assessed understanding and behavioural beliefs about the efficacy of the ten specified biodiversity behaviours (Table 3).

### Behavioural beliefs and past behaviour

Behavioural beliefs can be considered a measure of an individual's evaluation of the efficacy, and thus the value or advantage in undertaking a particular action (Ajzen & Fishbein 2005). Therefore, behavioural beliefs influence whether the attitude towards that action (behaviours) will be favourable or unfavourable. There was a high level (ranging from 69–98%) of belief in the efficacy of the listed ten on-farm practices to protect New Zealand's biodiversity as a whole (Table 1). Individual farmers were generally clear in their beliefs with few ($\bar{x}$ = 2.4% across the ten practices) providing an unsure response.

However, fewer farmers had implemented these same practices on their farms (Table 1), with a mean gap between belief in efficacy (behavioural belief) and actual behaviours of 22.5%. This gap ranged from 2.2% (undertaking weed control other than pasture weeds) to 52% (legally protecting areas of biodiversity on the farm). The most frequently undertaken behaviours were the four practices of controlling invasive fauna and flora species, which were also the four highest ranking in terms of behavioural belief (91.8–98.4%). In contrast, the two least frequently undertaken practices, planting native species (48.8% of farmers) and legal protection (27% of farmers), are among the three behaviours considered by farmers to be least effective for protecting New Zealand's native biodiversity. These results tend to support an alignment between farmers' behavioural beliefs and their actual behaviours.

### Farmer agreement with TPB variables

Overall, most of the surveyed farmers agree or strongly agree with each of the statements relating to the TPB variables (Fig. 2). Over half (55.8%; $n$ = 279) of the respondents strongly agreed that managing and protecting biodiversity on their farms helps enhance New Zealand's native biodiversity (a

**Table 3.** Correlation matrix ($n = 500$). All correlations (except those indicated with an *) are significant at $p \leq 0.001$. Values for all variables are based on a 5-point Likert scale except for variables indicated with an asterisk (*) where the mean is based on a 10-point constructed scale.

| | Understanding of biodiversity | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| *Independent variables* | | | | | | | | | |
| 1. Attitude to behaviour | 0.31 | | | | | | | | |
| 2. Moral obligation | 0.18 | 0.66 | | | | | | | |
| 3. Evaluative beliefs – public benefit | 0.23 | 0.66 | 0.63 | | | | | | |
| 4. Evaluative beliefs – private benefit | 0.19 | 0.53 | 0.48 | 0.51 | | | | | |
| 5. Perceived social norm | 0.19 | 0.57 | 0.54 | 0.57 | 0.60 | | | | |
| 6. Perceived behaviour control | 0.19 | 0.36 | 0.32 | 0.25 | 0.27 | 0.28 | | | |
| 7. Behavioural beliefs (efficacy)* | 0.12* ($p = 0.007$) | 0.19 | 0.17 | 0.29 | 0.25 | 0.30 | 0.02* ($p = 0.74$) | | |
| *Dependent variables* | | | | | | | | | |
| 8. Behavioural intention | 0.30 | 0.70 | 0.57 | 0.55 | 0.44 | 0.52 | 0.37 | 0.15 ($p = 0.001$) | |
| 9. Past biodiversity behaviour* | 0.30 | 0.43 | 0.36 | 0.37 | 0.39 | 0.37 | 0.20 | 0.31 | 0.40 |

Note: Bonferroni corrected alpha for significance = $p < 0.003$. All reported correlation $p$-values are uncorrected, observed values.

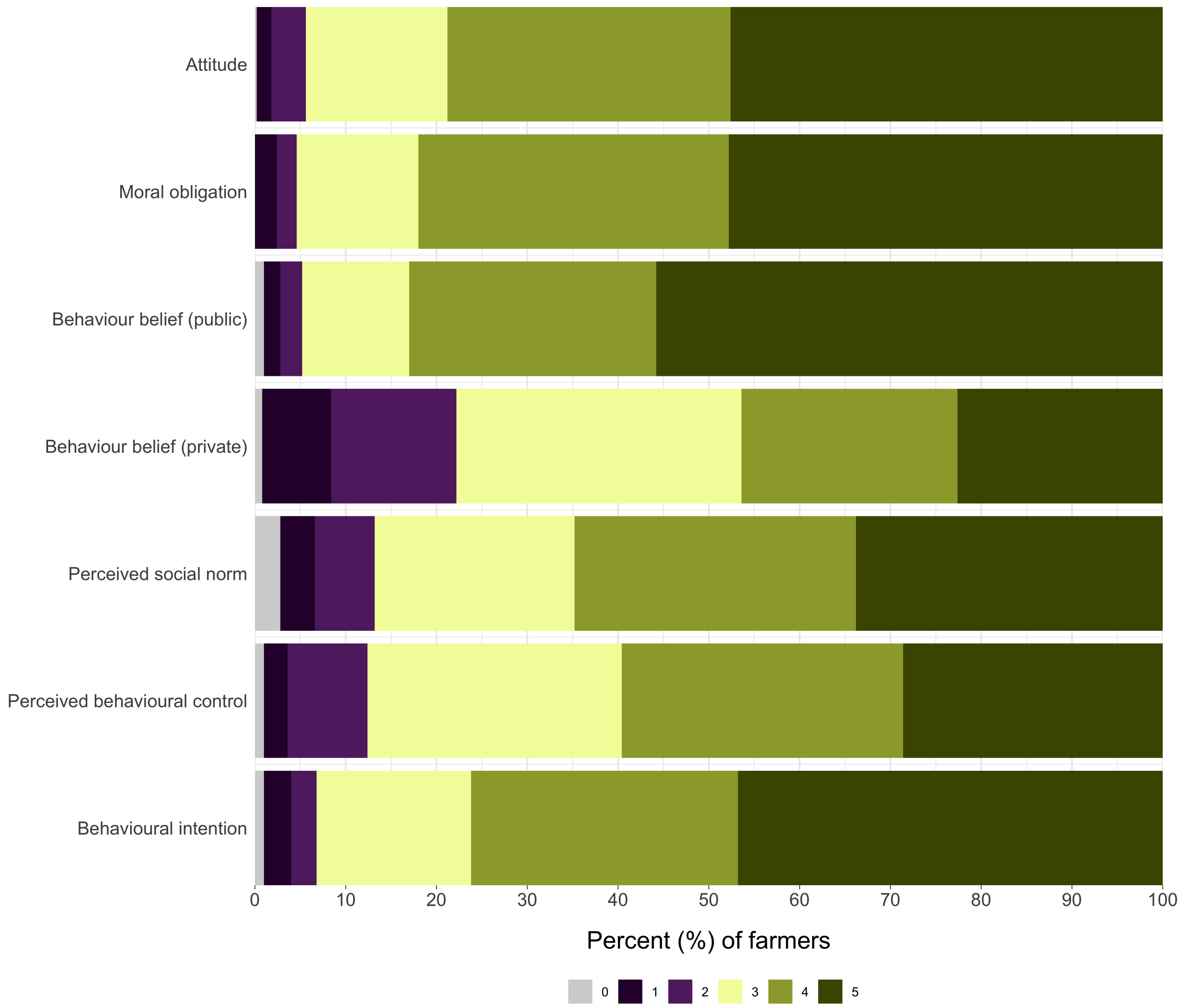


**Figure 2.** Percentage of farmers ($n = 500$) agreeing or disagreeing with the seven statements relating to key components of TPB.

public benefit). However, nearly a third (31.4%; $n$ = 157) of surveyed farmers were neutral and less than half agreed (23.8%; $n$ = 119) or strongly agreed (22.6%; $n$ = 113) that enhancing biodiversity on-farm improves their farm system. (Fig. 2). These results suggest that in evaluating outcomes from managing biodiversity on-farm, surveyed farmers perceived greater benefit to the public than to themselves and their farming enterprises.

Less than one-third of surveyed farmers agreed (31%; $n$ = 155) or strongly agreed (28.6%; $n$ = 143) they had the necessary skills and resources to enhance biodiversity on-farm. A further 28% ($n$ = 140) were neutral (Fig. 2); suggesting there are perceived controls and barriers influencing or preventing pro-biodiversity behaviour.

### Descriptive statistics for all TPB variables

Mean scores for all the TPB variables are above the mid-point of their scale (Table 2), indicating that farmer responses regarding all these construct variables are positive towards the protection of biodiversity. In line with the strong perception of public benefit, behavioural belief (in outcome efficacy of the set of specified biodiversity behaviours) was very strong. Moral obligation for biodiversity protection scored highly ($\bar{x}$ = 4.23; $n$ = 500) indicating that surveyed farmers strongly perceive protecting native biodiversity on-farm as a moral issue. Attitude towards protecting and managing biodiversity ($\bar{x}$ = 4.2; $n$ = 499), behavioural beliefs ($\bar{x}$ = 8.84; $n$ = 500), and behavioural intention to protect and manage biodiversity ($\bar{x}$ = 4.15; $n$ = 495) also scored very highly. Perceived social norm was positive, though moderate, indicating a perception of moderate social pressure to protect biodiversity.

### Correlations between predictors and criteria

There are strong intercorrelations between the independent variables attitude to biodiversity behaviour, moral obligation, belief in the public benefit arising from protecting biodiversity, belief in the private benefit of biodiversity behaviour, perceived social norms and behavioural beliefs (Table 3). Strong correlations between the predictor variables suggest there is redundancy in the set and some predictors will drop out of the regression models. Correlations between the independent variables and the dependent variable behavioural intention are significantly stronger than the correlations between the independent variables and the past behaviour dependent variable (Table 3).

There were two exceptions. First, the self-assessed understanding of the term biodiversity had a significant medium sized correlation $r(498) = 0.30$, $p < 0.001$ with both intention and past behaviour. The second is belief in the efficacy of the ten specified biodiversity behaviours, which returned a correlation of $r(498) = 0.15$, $p = 0.001$ and $r(498) = 0.31$, $p < 0.001$ with intention and past behaviour respectively. This result suggests that behavioural belief has a stronger relationship with actual behaviour than with behavioural intent.

The correlation between past behaviour and intention was a medium effect size $r(498) = 0.40$, $p < 0.001$ (Table 3). The independent variables are more strongly related to behavioural intention than to actual (past) behaviour. All hypothesised correlations were positive and significant ($p < 0.001$) and therefore the null hypotheses are rejected, and all 17 alternative hypotheses are supported, with attitude to biodiversity being the strongest of the predictor variables for both behavioural intention and past behaviour (Table 4).

### The influence of having biodiversity behaviours embedded in farm plans

A one-tailed independent $t$-test was conducted on the biodiversity behaviour score between having a farm plan that included actions to improve biodiversity ($n$ = 204, $\bar{x}$ = 7.40, $SD$ = 1.70) and all other cases (i.e., no farm plan and farm plan without actions to improve biodiversity included) ($n$ = 296, $\bar{x}$ = 6.16, $SD$ = 1.95). The difference was significant ($p < 0.001$) regarding the number of past pro-biodiversity behaviours implemented. The effect size difference between

**Table 4.** Summary of behavioural intention and past behaviour alternative hypotheses.

| **Alternative hypothesis (Ha: $p > 0$)** | **Correlation coefficient ($r$)** | **Effect size** | **Significant ($p < 0.003$)*** | **Reject/support** |
|---|---|---|---|---|
| *A positive relationship exists between behavioural intention and…* | | | | |
| …self-perception of understanding of the term 'native biodiversity' | 0.30 | Medium | Yes | Support |
| …attitude to biodiversity (importance placed on its management and protection) | 0.70 | Large | Yes | Support |
| …feelings of moral duty to manage and protect biodiversity | 0.57 | Large | Yes | Support |
| …public benefit | 0.55 | Large | Yes | Support |
| …private benefit | 0.44 | Medium | Yes | Support |
| …perceptions of social norms (expectations of important others) | 0.52 | Large | Yes | Support |
| …perceived behavioural control (have the necessary skills and resources) | 0.37 | Medium | Yes | Support |
| …behavioural beliefs – outcome evaluation | 0.15 | Small | Yes | Support |
| *A positive relationship exists between past behaviour* | | | | |
| …self-perception of understanding of the term 'native biodiversity' | 0.30 | Medium | Yes | Support |
| …attitude to biodiversity (importance placed on its management and protection) | 0.47 | Medium | Yes | Support |
| …feelings of moral duty to manage and protect biodiversity | 0.36 | Medium | Yes | Support |
| …public benefit | 0.37 | Medium | Yes | Support |
| …private benefit | 0.39 | Medium | Yes | Support |
| …perceptions of social norms (expectations of important others) | 0.37 | Medium | Yes | Support |
| …perceived behavioural control (have the necessary skills and resources) | 0.20 | Small | Yes | Support |
| …behavioural beliefs – outcome evaluation | 0.31 | Medium | Yes | Support |
| …behavioural intention | 0.40 | Medium | Yes | Support |

* Bonferroni corrected alpha value for significance is $p < 0.003$

the means was calculated using Hedge's $g = 0.67$, a medium strength effect. Thus, our results reject the null hypothesis and support our alternate hypothesis: farmers who have specific pro-biodiversity behaviours included in a farm plan are more likely to have, or be currently, implementing pro-biodiversity behaviour on-farm. These results indicate the value of including specific pro-biodiversity behaviours and goals in a farm plan for enhancing farmers' native biodiversity practice.

**Behavioural intention regression model**

Three, four, and five variable models were suggested by the best subsets and stepwise regression procedures for behavioural intention. The three variable model proved to best match the various fit indices. The three-variables selected by regression analyses as the best predictors of behavioural intention are the three proximal TPB predictors: attitude to the behaviour ($t = 13.84$, $p < 0.001$), perceived social norms ($t = 4.24$, $p < 0.001$), and perceived behavioural control ($t = 3.34$, $p = 0.001$) (Table 5). Attitude is the strongest predictor, explaining 49% of the variance of behavioural intention. Ajzen and Fishbein (2005) note that the relative strength of the relationship of the three predictor variables to the criterion varies across different behavioural domains. The TPB model explains 51.6% of the variance in behavioural intention (Table 5).

**Past behaviour regression model**

Both the best subset regression and the stepwise regression suggested the same four-variable model for past behaviour. The model variables were self-assessed understanding of the term biodiversity ($t = 3.89$, $p < 0.001$), attitude to biodiversity behaviour ($t = 5.54$, $p < 0.001$), private benefit ($t = 3.65$, $p < 0.001$) and behavioural belief in efficacy of behaviours to enhance New Zealand's native biodiversity ($t = 4.91$, $p < 0.001$) (Table 5). As with the behavioural intention model the strongest predictor was attitude to biodiversity behaviour ($R^2 = 18.4\%$). This model explained 29.13% of the past biodiversity behaviour (Table 5). Because behavioural intention is considered the best predictor of and is often used as a proxy for actual behaviour, we also ran a regression analysis for past behaviour as the dependent variable with the three TPB variables that best predicted behavioural intention. However, the fit of this latter model was considerably inferior on all fit indices with an adjusted $R^2$ of 21.18% (Table 5).

## Discussion

Our study shows that surveyed farmers self-assessed as having a good understanding of native biodiversity and a reasonably high level of belief in the efficacy of specific on-farm practices to protect and manage New Zealand's native biodiversity. Three notable findings provide key learnings for the design and implementation of policy initiatives. First, surveyed farmers' saw greater public than private benefit resulting from the protection and management of native biodiversity on-farm. Second, behavioural belief in the efficacy of biodiversity behaviours has a stronger relationship with actual behaviour than with behavioural intention. Third, having biodiversity behaviours in a farm plan increases farmer pro-biodiversity behaviour. Our study also suggests room for improvement in farmers' understanding of the concept of protecting native biodiversity and the types of behaviours that are efficacious. Farmer stated belief in the efficacy of the set of biodiversity behaviours was not fully reflected in their actual behaviour indicating that, for some on-farm practices at least, control beliefs and behaviour controls are influencing intentions and actual behaviours.

Our findings suggest that policy initiatives should be targeted at (1) illustrating and communicating the multiple values of native biodiversity to farm systems and farming enterprises (private benefit), and to ecosystem function and New Zealand's conservation objectives as a whole (public benefit); (2) the specific areas operating as behavioural controls on pro-biodiversity behaviour i.e. barriers and enablers of on-farm pro-biodiversity behaviour; and (3) integrating biodiversity considerations into a farm plan.

**Model limitations**

Our TPB model has several limitations that need to be considered. In particular, the method of using a simple, total, unweighted score for developing the biodiversity behaviour score may attenuate its construct validity. However, due to heterogeneity of farm context, not all of the ten practices were relevant to all farms or farmers (e.g. feral herbivores may have been absent in some situations, and possum control may have been managed by an external agency). Therefore, our past biodiversity behaviour measure will, to an undefined extent, contain error that reduces its validity as a measure of the construct of biodiversity behaviour. However, our approach to determining a biodiversity score balanced the integrity of the data with time restrictions associated with ethical telephone interview data collection. Further, the correlation of the biodiversity past behaviour score with hypothesised predictor variables (e.g. attitude to biodiversity behaviour, moral obligation, public and private benefit outcome evaluations, perception of social norms, and behavioural beliefs (about the efficacy of biodiversity behaviours) indicates that our past behaviour biodiversity score is capturing enough of the construct of protection and management of biodiversity behaviour to be a useful experimental measure.

Similar limitations are associated with measurement of our independent variables that were largely imposed from time restrictions for telephone surveys limiting the number of question items able to be posed. Therefore, rather than using

**Table 5.** Regression equation and model summary for behavioural intent and past/current behaviour.

| Model | S | R-sq | R-sq(adj) | PRESS | R-sq(pred) | AICc | BIC | 10-fold S | 10-fold R-sq |
|---|---|---|---|---|---|---|---|---|---|
| *Behavioural intent* | 0.698884 | 51.62% | 51.31% | 235.939 | 50.48% | 1015.87 | 1036.57 | 0.706441 | 50.15% |
| = 0.638 + 0.5972 Attitude to behaviour + 1.0535 Perceived social norm + 0.1096 Perceived behavioural control | | | | | | | | | |
| *Past/current behaviour* | 1.64597 | 29.13% | 28.51% | 1279.03 | 27.42% | 1794.05 | 1818.73 | 1.65791 | 27.32% |
| = 0.191 + 0.2632 Understand term 'native biodiversity' + 0.558 Attitude + 0.3000 Private benefit + 0.2407 Behavioural belief | | | | | | | | | |

multiple items to measure the independent variable constructs, we used a single-item for most constructs. For example, attitude was tested in the context of native biodiversity generally, rather than specific components of native biodiversity. This aggregated representation of biodiversity means that the reliabilities of the independent variables' measures are unknown. As with our composite past behaviour biodiversity scores, the predicted, observed directional correlations found between the dependent variables and the independent variables give confidence that the measures have useful levels of construct validity.

The behavioural intention criterion measure is a direct self-report of intent and as such is typically used in research as a proxy for future behaviour (Ajzen & Fishbein 2005). Behavioural intention is a hypothetical future-oriented measure. We argue that past behaviour, because it directly asks people "what are/did you actually do?", will likely evoke less social desirability (the tendency to give positive self-descriptions; Paulhus 2002) and maximal performance responding (individuals who know they are being evaluated maximise their performance; Klehe et al. 2007), than behavioural intention, which essentially asks respondents the hypothetical "what will you do in the future?" Maximal performance, social desirability responding, and optimistic perceptions of behavioural control factors are likely to boost the strength of the behavioural intention measure, and consequently behavioural intentions will likely be higher than actual behaviour as shown by our study and is consistent with previous research (Ajzen & Fishbein 2005).

**Policy intervention to improve biodiversity outcomes on-farm**

We consider the past behaviour model to be a more realistic model of actual behaviour than the future-oriented behavioural intention model, and that the higher measure of intentional behaviour expressed by our study is unlikely to translate to actual behaviours to the same degree. Therefore, it will be critical to design policy to help bridge the gap to achieve better biodiversity outcomes on-farm. Public policy has a key role to play in bringing about behaviour change via interventions that nudge, compel, or incentivise desired behaviours (Pannell 2008). We suggest that policy initiatives and interventions to enhance on-farm biodiversity behaviour amongst New Zealand farmers can be informed by the explanatory variables in our past behaviour model. This is supported by numerous behaviour change intervention studies that have found information targeted at the TPB predictors can achieve a significant change in the target behaviour (Fishbein et al. 1980; Brubaker & Fowler 1990; Van Ryn & Vinokur 1992; Fishbein et al. 2001).

We suggest future policy initiatives and interventions specifically to respond to the following key areas of need as identified by the TPB analysis:

(1) Enhancing farmers' attitude to pro-biodiversity behaviour by:
(a) enhancing farmers' understanding of what native biodiversity is;
(b) increasing farmers' awareness and understanding of the range and efficacy of pro-biodiversity on-farm behaviours for enhancing New Zealand's native biodiversity,
(c) increasing farmers' awareness about the private benefits of enhancing native biodiversity in their farm system,
(2) enhancing knowledge of the positive social norm regarding on-farm biodiversity behaviour (a nudge),
(3) ameliorating barriers to perceived and actual behavioural control and providing incentives to mitigate perceived and actual costs,
(4) encouraging farm relevant pro-biodiversity actions in farm plans (goal setting).

Pannell (2008) argued that to choose the most appropriate type of policy instrument to help bring about the desired on-farm environmental behaviour, it is important to understand the degree to which the farmer privately benefits from the behaviour and the degree to which the public benefits. Our study showed that private benefit is an important motivational factor of past (actual) biodiversity behaviour of our farmer sample. The most frequently undertaken behaviours (the four practices of controlling invasive fauna and flora species), were also the four highest ranking in terms of behavioural belief. While these behaviours are strongly efficacious in protecting and enhancing native species (Fitzgerald et al. 2021), a clear public benefit, the resulting enhanced biodiversity values also have clear private benefits for the farmer.

Therefore, we suggest that research demonstrating, in farmer-relevant contexts, the multiple values of enhancing native biodiversity, be undertaken as a priority and in parallel with economic and practical incentives to overcome control constraints. The former is currently occurring to some degree, e.g. illustrating the value of increasing biodiversity stocks to farm productivity (Dominati et al. 2019); we suggest such initiatives need to continue and expand, and those findings are communicated transparently.

Whole farm plans (plans that integrate environmental, social and economic goals, and capture enterprise development) provide an existing and useful mechanism by which to integrate biodiversity considerations into farm planning processes on an equal footing with other aspects of the farm business (Maseyk et al. 2019; Maseyk et al. 2021b). Incorporating biodiversity considerations into farm plans also ensures pro-biodiversity behaviours are farm-relevant, and farmers are psychologically involved in the process of setting goals and forming implementation plans. This is critical for success as relevance (Ajzen & Fishbein 2005), involvement (Sivacek & Crano 1982), goal setting (Locke & Latham 2006), and implementation planning (Gollwitzer 1999) are all factors that have been found to enhance goal performance and reduce the attitude-intention-behaviour gap. Additionally, forming an implementation plan is believed to increase goal performance by increasing awareness of situational cues which when encountered stimulate the initiation of goal-directed behaviour (Gollwitzer 1999).

To address and help reverse biodiversity declines in New Zealand, it will be necessary to involve farmers. Our study shows that farmers are generally aware of native biodiversity and have high self-identified levels of participation in some aspects of biodiversity management and protection. However, there is both the need and the potential for greater farmer participation in pro-biodiversity behaviours on-farm.

Increasing farmer participation in the management and protection of native biodiversity will require a mix of approaches that include voluntary, regulatory, and economic policy instruments as well as increased availability of information. Collectively, these approaches will help provide the necessary knowledge, assistance, and resources from trusted sources; defining and enforcing socially acceptable behaviours and environmental bottom lines, and creating positive and lasting incentives for farmers to practice biodiversity behaviour and balance out perceived costs. Finally, integration of biodiversity considerations in a farm plan utilises several psychological principles that may enhance farmer pro-biodiversity performance and reduce the intention-behaviour gap.

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## Author contributions

Both authors led the survey development. BS led the theoretical underpinning of the survey design and undertook the analysis. Both authors contributed to the data presentation and wrote the manuscript.

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