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Management of bovine tuberculosis (TB): Investigation of the non-market biodiversity benefits to New Zealand residents of TB-possum control

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June 2014

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Contents

List of Tables

List of Figures

Key Points

- The AERU at Lincoln University, in collaboration with Landcare Research, has estimated economic values for the conservation benefits that the NZ public gain from the biodiversity protection in native forests that result from possum control conducted as part of New Zealand's TB management programme.

- There are no observable market prices that reveal what the New Zealand public are willing to pay for native biodiversity benefits that flow from TB-possum control. A non-market valuation methodology, choice modelling, was therefore used. This involved an online survey of New Zealand residents in February 2014.

- The survey process achieved 813 responses (14.5%) with good representation of key population demographics.

- The responses to subsidiary question (i.e.; not specifically part of the choice experiments) demonstrated strong public support for the conservation outcomes of TB-possum control in public native forest programme. Generally, residents indicate a strong preference for improved protection of native biodiversity.

- The choice-modelling experiment shows that respondents place substantial value on biodiversity benefits of TB possum control. Specifically, in the native forest in which TB-possum control is conducted, and relative to (i.e.; in addition to) the conservation benefits delivered elsewhere by the Department of Conservation (DOC), respondents were willing to pay (WTP);

    - $2.01 for each 1% increase in protection of forest canopies
    - $0.72 for each 1% increase in protection of native birds
    - $0.50 for each 1%increase in protection of within-forest plants
    - $0.35 for each 1% increase in protection of large native invertebrates

- Simple extrapolation of the marginal WTP estimates to the national scale generates a national estimate of hundreds of millions of dollars annually. Adjusting this for worst-possible-case non-response bias and for reduced WTP for benefits that do not endure beyond the short-term, and allowing for the ecosystem responses being much lower than depicted in some forest types and for ground control relative to aerial control, we derive a minimum estimate of current national benefits from the conservation outcomes achieved in the order of $56m annually. This minimum estimate assumes that 85% of New Zealanders would not pay anything for the improved conservation outcomes, so the adjusted estimate would quadruple if WTP of non-respondents was half that of respondents.

- Some conservation benefits, particularly canopy recovery, would endure until at least the medium term even if all TB-possum control in native forest ceased immediately. The NPV of future benefits from current outcomes was calculated at $621m over a 35 year period at an 8% discount rate. The large size of the this estimate primarily reflects the substantial protection to forest canopies provided by TB-possum control, and the likelihood that that benefit will endure for several decades, coupled with high public WTP for those durable improvements. If the same amount (total area) of control was maintained for the next 15 years this increases to about $712m, with the small increase largely reflecting the heavy discounting of the long-term benefits of that future control.

1 Introduction

Bovine tuberculosis (TB) is a disease of cattle (and deer) that can also affect humans, and was once a major threat to New Zealand's important dairy, beef and deer industries. However, intensive management of TB by testing and culling of farmed cattle and deer, and intensive control of Australian brushtail possums (*Trichosurus Vulpecula*; the main wildlife host of the disease), have resulted in a >95% reduction in TB levels in livestock since 1994. The TB management programme (which is managed by TBfree New Zealand) costs ~$80m annually, with almost two-thirds of that spent on TB-related control and surveillance of the main wildlife hosts (hereafter referred to for convenience as TB-possum control). The programme is funded by a combination of levy payments from dairy, cattle, and deer farmers and contribution to possum control by central and local government.

TB-possum control is conducted over about 8 million hectares (~30%) of New Zealand, comprising about 80% of the area believed to contain TB-infected wildlife – these areas are designated Vector Risk Areas (VRAs). Outside those areas, no TB-possum control is conducted in the remaining 'Vector Free Areas'; i.e. farmers in those areas pay for TB-possum control elsewhere. TB-possum control inside VRAs not only greatly reduces the levels of TB in wildlife (and therefore the risk of TB transmission from possums to livestock), but also reduces the extent to which possums compete with livestock, or damage production or erosion control trees or ornamental plantings, or damage native ecosystems by killing possum-vulnerable trees and plants and preying on native birds and insects.

In addition some forms of TB-possum control (most notably aerial 1080 poisoning) also temporarily reduces the densities of rats, stoats, and other pests, potentially reducing the threat those pest pose to biodiversity and other values. A recent report (Jenkins 2012) produced for the Animal Health Board (AHB) took the view that on-going crown funding was likely to be partly dependent on quantifying the 'biodiversity' benefits. However, those benefits have been only partially quantified in biological terms, and not valued at all in economic terms. The aim of this project was to begin to address that knowledge gap.

Our objective was to determine, in economic terms, the likely value of some of the nonmarket benefits to conservation that accrue from TB-possum control by completing a initial investigation to value New Zealanders place on the biological benefits to native species in native forest. We used a Choice Modelling approach involving an online survey of the general public. The project involved collaboration between the Agribusiness and Economics Research Unit (AERU) at Lincoln University and Landcare Research.

Results are presented in two parts. The first section (3.2) summarises the responses to a series of survey questions exploring public perceptions and experiences of native forests. The second section (3.3) presents results from the choice modelling component of the survey including estimates of benefits to the New Zealand public for various biodiversity outcomes.

2 Method

2.1 Overall Approach

An Internet-based survey of New Zealand residents was conducted in February 2014 using names and contact details obtained from a database maintained by Research Now (reserachow.com). The final sample consisted of 813 residents from throughout New Zealand.

The survey was administered using an online survey mode employing Qualtrics™ online survey software, and proprietary software for implementing choice modelling surveys maintained by AERU. The process consisted of contact through an email invitation to residents that contained a link to the survey online.

2.2 Choice Modelling

There are no observable market prices available that reveal what New Zealand residents are willing to pay for the types of conservation benefits that flow from the TB-possum control programme. We therefore employed a non-market valuation methodology, of which choice modelling was deemed appropriate. Choice modelling has, for over four decades, been applied in economics to a wide variety of goods and services such as transport, cultural heritage, environmental quality and health care. Internationally this approach has been widely applied to value biodiversity[1] and has been recently applied in New Zealand to plantation forest[2].

Choice modelling is a survey-based method in which respondents are presented with a series of choice tasks. For each choice task, respondents choose between at least two broad options. In this study, the options represent alternative management scenarios for a TB-possum control programme. Each option is described by a number of characteristics or attributes, which could describe the outcomes of the particular scenario, e.g. improved protection of native forest canopy trees, and native birds. In each choice task, the combinations of characteristics are systematically varied to denote different types of management options. Respondents are asked to choose the combination of outcomes they prefer. We assume that the options chosen by respondents are what they think are best for them personally.

Statistical information derived from these choice tasks was econometrically modelled to quantify the relative importance of each programme characteristic. By including one key monetary attribute in choice tasks, the monetary value of other non-monetary attributes can be calculated. Economists express this as willingness to pay, e.g. how much I am willing to

[1]Czajkowski M, Buszko-Briggs M, Hanley N. 2009. Valuing changes in forest biodiversity. Ecological Economics, 68:2910-2917.

[2]Yao R, Scarpa R, Turner JA, Barnard TD, Rose JM, Palma JHN, Harrison DR. 2014. Valuing biodiversity enhancements in New Zealand's planted forests: Socioeconomic and spatial determinants of willingness-to-pay. Ecological Economics, 98:90-101.

pay to have a programme that improves protection of native birds. Therefore this value can be used as the monetary estimate of the benefit of this programme attribute.

2.3 Survey Design

The full public survey can be found Appendix A. Exploring and finalising the choice of biodiversity attributes that describe the outcomes of TBfree management in native forest was undertaken primarily with the ecological expertise of Landcare Research staff in conjunction with review and discussion with TBfree staff. A workshop involving the research team and some of New Zealand leading 'biodiversity' researchers was convened in late 2013. It aimed to agree on what biological changes in ecosystems were likely to result for TB-possum control in native forest, and how those changes could be characterised in the very simple terms required for an online survey. Four areas of impact or probable conservation benefit were identified as the ecological responses that could be characterised as the 'outcome attributes' of Tb possum control that would be relevant in the context of a national level survey: canopy tree species, large native invertebrates, native birds, and within-forest plants.

In addition to the nature of the outcome attributes, we characterised the scale of the conservation outcomes by determining by how much TB-possum control was conducted in native forest on public land, depicted as the red areas in Fig 1.

To guide construction of the possible range of biodiversity protection scenarios and consequent outcomes, four scenarios were developed (in consultation with TBfreeNZ) spanning a wide range of potential changes in the amount of pest management effort, ranging from a major reduction in effort to a major increase, as follows:

1. Little or no TB-possum control in native forest on public land (resulting in no substantial increase in protection above DOC levels)
2. TB-possum control only
3. Frequent TB possum and rat control
4. Frequent possum, rat, and predator control

Scenario 1 represent either the complete cessation of Tb possum control, or (more realistically) the so-called Ad-hoc scenario developed and evaluated in the 2008 review of the NPMP in which the National Pest Management Plan for TB is abandoned, and local possum control (mostly on- or near-farm only) is undertaken by industry and landowners. We assumed under that scenario that little of the current TB-possum control in native forest on public land would continue.

In the process of developing the attributes that would represent TB-possum control outcomes, we considered that an appropriate framing would be to present an outcome that was measured relative to the conservation benefits and biodiversity protection that the Department of Conservation (DOC) currently provides. This was intended to enable respondents to consider

how TB-possum control benefits compared in scale and intensity to the conservation benefits that they paid for (through taxes) DOC management of biodiversity. It gave respondents the ability to express their preference for benefits that added to those delivered by DOC. The complex nature of the ecological outcomes, and possible unfamiliarity by respondents to the goods being valued led us to develop simple pictorial representations of potential management outcomes that were included alongside the text descriptions of outcomes in the choice experiment. The ranges of levels of outcomes for each attribute were determined based on probable outcomes associated differing amounts of management effort. These are described and presented as outcomes relative to the situation in which little TB-possum control occurs in publicly owned native forest, and therefore any biodiversity outcomes above and beyond those provided by DOC are assumed to be at low levels.

The set of biodiversity attributes, and the levels within those, that were finally agreed upon are presented in Table 1[3]. In the survey, the different levels of each attribute are systematically combined (using an experimental design) to form the choice tasks. Each choice task contains the 'No TBfree management' outcomes, paired with two options depicting different levels of outcomes with management. Each respondent was asked to complete six choice tasks and an example is shown in Figure 2.

[3] The vector of tax payment levels was constructed based on review of relevant literature and survey pre-testing.

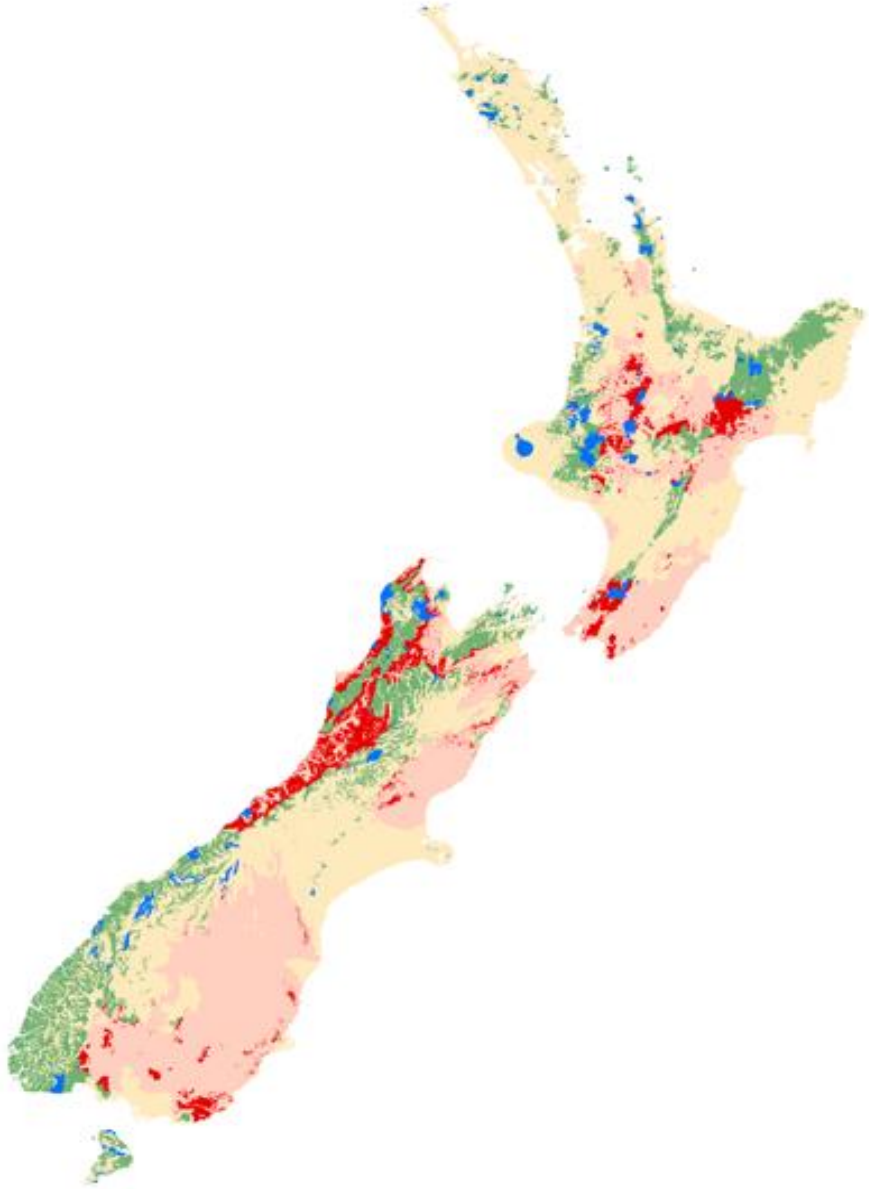


Figure 1. TBfree NZ and DOC pest management in native forest

Areas shaded green are native forest in which possum are not managed, while the areas in blue DOC carries out pest management and the area in red depicts native forest where TBfree NZ conducts TB-possum control. The pink areas show where TB-possum control is conducted outside native forest.

Table 1. Attribute descriptions and levels for choice tasks

Native forest biodiversity attributes	No TBfree management No increase in protection above DOC level	TBfree management levels Increase in protection above DOC levels		
		TB-only possum control	Frequent TB possum and rat control	Frequent possum, rat and predator control
Canopy tree species	 **Heavy browse and dieback** of vulnerable canopy species	 **Most** Tbfree managed forest with healthy unbrowsed trees. **140%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed trees. **150%** increase in protection above DOC level	
Large native invertebrates	 All large native invertebrate populations **severely affected**	 **Some** possum-vulnerable large invertebrates partially protected but most still affected. **20%** increase in protection above DOC level	 **Most** vulnerable large invertebrates well protected but a few still affected. **120%** increase in protection above DOC level	 **All** large invertebrates protected in TBfree managed forest. **150%** increase in protection above DOC level
Native birds	 All native birds threatened by possums **severely affected**	 **Some** possum-vulnerable native birds partially protected. **25%** increase in protection above DOC level	 **Most** possum-vulnerable native birds protected. **100%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy native bird populations. **150%** increase in protection above DOC level
Within-forest plants	 All within-forest plants **heavily defoliated**	 **Some** but not all vulnerable within-forest plants protected **100%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed within-forest plants **150%** increase in protection above DOC level	
Annual tax contribution	$0	$25, $50, $75, $100		

Set 1 of 6 Each *column* describes a management option. Which of the following management options would you prefer? Select your choice and click on **>>** below.

	No TBfree management	TBfree management option A	TBfree management option B
Canopy tree species	 **Heavy browse and dieback** of vulnerable canopy species No increase in protection above DOC level	 **Most** Tbfree managed forest with healthy unbrowsed canopies **140%** increase in protection above DOC level	 **Most** Tbfree managed forest with healthy unbrowsed canopies **140%** increase in protection above DOC level
Large native invertebrates	 All large native invertebrate populations **severely affected** No increase in protection above DOC level	 **Most** possum-and rat-vulnerable large invertebrates well protected but a few still affected **120%** increase in protection above DOC level	 **Some** possum-vulnerable large invertebrates partially protected but most still affected **20%** increase in protection above DOC level
Native birds	 All possum-vulnerable native birds **severely affected** No increase in protection above DOC level	 **Some** possum-vulnerable native birds partially protected **25%** increase in protection above DOC level	 **Most** possum-vulnerable native birds protected **100%** increase in protection above DOC level
Within-forest plants	 All within-forest plants **heavily defoliated** No increase in protection above DOC level	 **Some** but not all vulnerable within-forest plants protected **100%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed within-forest plants **150%** increase in protection above DOC level
Annual tax contribution	$0	$75	$50
Selection	○	○	◉

Figure 2. Example of a choice task presented to respondents

3 Results

3.1 Sample Characteristics

The sample of respondents was obtained from Research Now (researchnow.com), a research consultancy that provides analytical services and maintains one of the largest global databases of survey respondents. Their panel of members is paid for completed surveys. This sampling method allowed for the pre-stratification of the sample by age, gender, education, occupation, income, household size, and location. That would not be possible if drawing a sample from the commonly used Electoral Roll (because most of these variables are not available in this sampling frame).

The sampling process achieved an effective response rate of 14.5%. A total of 813 respondents completed the choice modelling questions, and an additional 79 respondents answered the other questions in the survey, but not the choice modelling questions. This is considered a good response rate given that typical response rates for email surveys are 10–15%. Choice-modelling surveys impose a greater than usual cognitive burden on respondents, so tend to have relatively lower response rates compared with more general surveys. Other forms of survey administration, such as in-person (face-to-face) surveying, tend to have a much higher response rate but are much more expensive.

Unlike mail-and-return survey modes where the sampling process is typically more prolonged and respondents are able return surveys over a longer timeframe, the sampling process used here concludes as soon as sampling quotas are met. This creates the possibility that residents who received an invitation were unable to respond before the survey closed, so the 14.5% response rate is likely to understate the number willing to respond.

Table 3 describes the composition of the sample by various demographic variables, including location. To determine whether the sample is representative of the general NZ population, we statistically tested the null hypothesis that the frequency distribution of the observed sample demographic variable was consistent with the population distribution of that variable, as provided by Statistics NZ 2013 data. The p-values in Table 3 indicate that the sample composition was overall a good representation of the NZ population, with only education being skewed towards higher levels relative to that of the general population. As this was a national survey we sought, and achieved (Figure 3), a geographically wide distribution of responses.

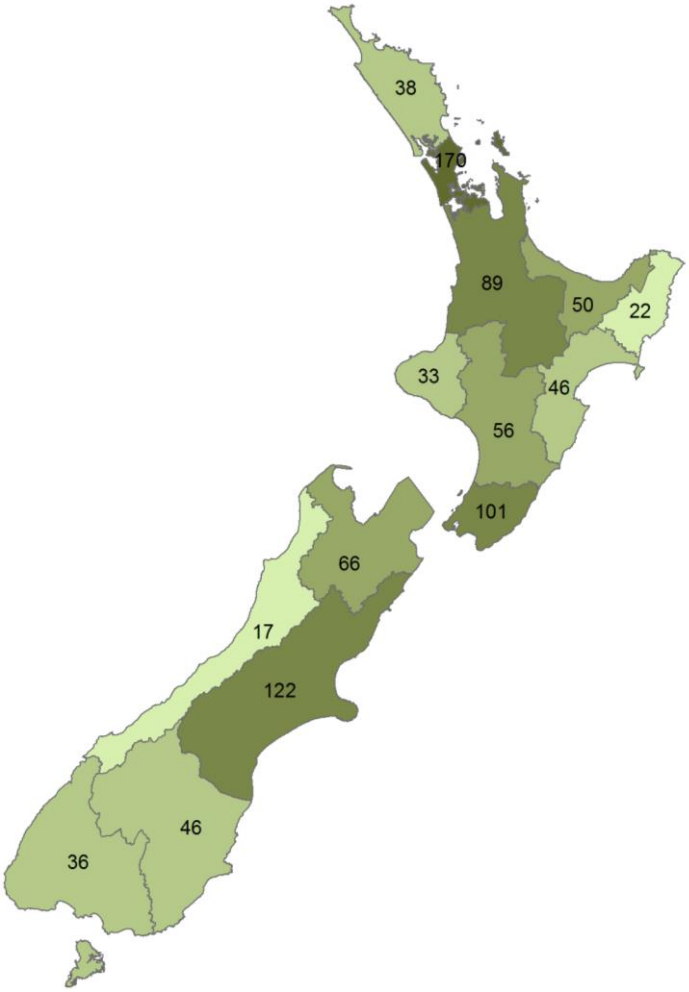


Figure 3. Geographical distribution of survey sample (counts)

Table 2. Sample characteristics

Demographic Variable		Sample Distribution (%)	NZ Population Distribution (%)[1]
Age [p = 0.75][2]	65 years or more	18	19
	55 – 64 years	19	15
	45 – 54 years	16	19
	35 – 44 years	15	18
	25 – 34 years	19	16
	18 – 24 years	13	13
Gender [p = 0.84]	Female	50	51
Education [p = 0.00]	High school	28	50
	Trade/technical qualification or similar	25	9
	Undergraduate diploma/certificate/degree	35	14
	Postgraduate degree	12	6
	None	1	21
Occupation[3] [p = 0.34]	Unemployed	4	4
	Retired	16	14
	Unpaid voluntary work	2	1
	Student	8	6
	Paid employment	50	59
	Home duties	8	8
	Self-employed	11	6
Household Income [p = 0.76]	Loss	2	1
	$0 - $20,000	12	13
	$20,001 - $40,000	22	24
	$40,001 - $50,000	11	6
	$50,001 - $70,000	15	15
	$70,001 - $100,000	16	16
	$100,001 or more	22	26
Household Size [p = 0.87]	One	17	22
	Two	37	34
	Three	19	17
	Four or more	28	27
Region [p = 0.23]	Auckland	19	33
	Bay of Plenty	6	6
	Canterbury	14	13
	Gisborne	2	1
	Hawke's Bay	5	4
	Manawatu-Wanganui	6	5
	Marlborough	2	1
	Nelson	3	1
	Northland	4	4
	Otago	5	5
	Southland	4	2
	Taranaki	4	3
	Tasman	3	1
	Waikato	10	10
	Wellington	11	11
	West Coast	2	1
Environmental Organisation Membership	Forest and Bird	4	
	Fish and Game	4	
	Environment and Conservations Organisations of NZ	2	
	Greenpeace	2	
	Other	3	
	None	85	

[1] Distributions from Statistics NZ Census 2013. [2] Values in brackets are P-values for Pearson's Chi-squared test of the null hypothesis that the frequency distribution of the observed sample demographic variable is consistent with the population distribution provided by Statistics NZ Census 2013 data. A p-value less than 0.1 indicate a statistically significant difference between the distributions. [3] Population distributions from 2013 Household Labour Force Survey.

3.2 Public Perceptions and Experiences of Native Forest

The survey began by asking respondents a series of questions designed to provide relevant context and framing for the survey that enables respondents to think about and recall what benefits that they perceived from native biodiversity outcomes in native forest. This aimed to help generate meaningful choices when they were presented with the choice tasks later in the survey. Although not the central focus of this project, the results help illustrate the wider context in which choices were made.

3.2.1 Importance of Native Forests

These questions included Likert-scale responses indicating the relative importance of various broader aspects of native forest to NZ such as attracting tourists, providing employment opportunities and enhancement of NZs international brand. This allows for exploration of the relative importance of native forest as providing habitat for native flora and fauna (the attributes valued in the choice experiment), against other aspects of value that the public derives from native forest.

'Providing habitat for native plants, animals and insects' is considered to be the most important aspect of those considered here, followed closely by 'preserving fresh water quality in rivers and streams' (Table 3). 'Encouraging commercial enterprises' was far less important with 44% of respondents indicating that this was not important to them. Overall, this analysis suggests that passive-use values are a more significant driver of importance to NZ residents, than direct-use activities. This means that, although many residents may not directly engage with native forests, they are still valued for the benefits they provide to the wider public, such as existence, bequest, and option values.

Table 3. Importance of native forest uses

What do you think are the most important aspects of native forests for New Zealand?	Rank	Very Important 1	2	Neither important or not important 3	4	Not Important 5	Don't know
Provide habitat for native plants, birds and insects	1	74%	16%	4%	3%	1%	1%
Preserving fresh water quality in rivers and lakes	2	69%	20%	6%	2%	1%	1%
Preserve resources for future generations	3	61%	25%	8%	3%	1%	1%
Preserving cultural and heritage values	4	37%	30%	19%	7%	4%	2%
Providing recreational opportunities	5	28%	41%	21%	6%	1%	2%
Enhancing New Zealand's international brand	6	31%	35%	22%	6%	3%	2%
Attracting tourists	7	25%	37%	25%	8%	4%	1%
Tramping	8	19%	39%	25%	10%	4%	2%
Providing employment opportunities	9	22%	30%	30%	12%	3%	2%
Fishing	10	16%	25%	31%	15%	10%	2%
Hunting	11	7%	18%	29%	22%	22%	1%
Encouraging commercial enterprises	12	7%	15%	30%	23%	21%	3%

3.2.2 Participation in Native Forest Based Activities

A small majority (59%) of respondents participated in at least one activity based in native forests (Figure 4). Tramping had the highest level of participation, while few undertook employment activities in native forest. One third of those who participated in some activity did so at least monthly (Figure 5), but few did so daily.

Figure 4. Participation in native forest based activities

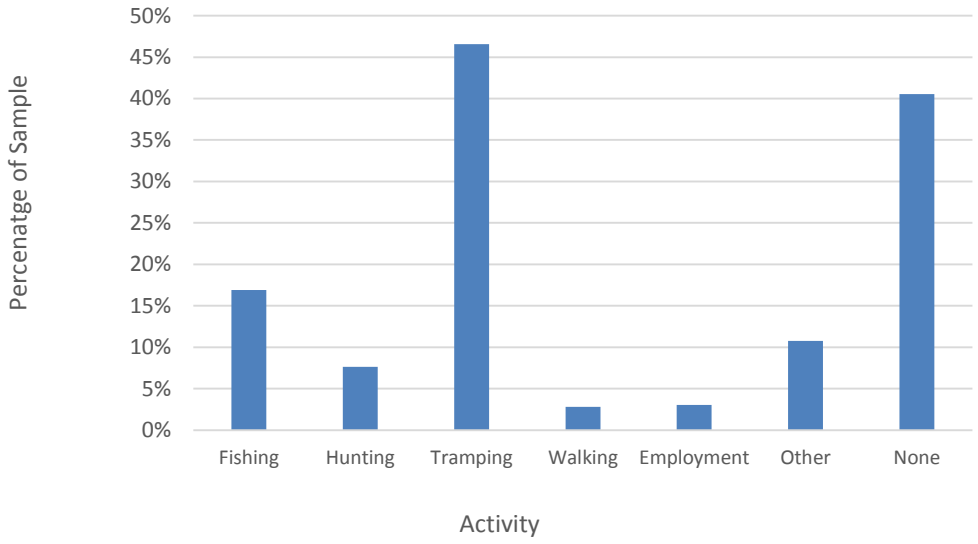
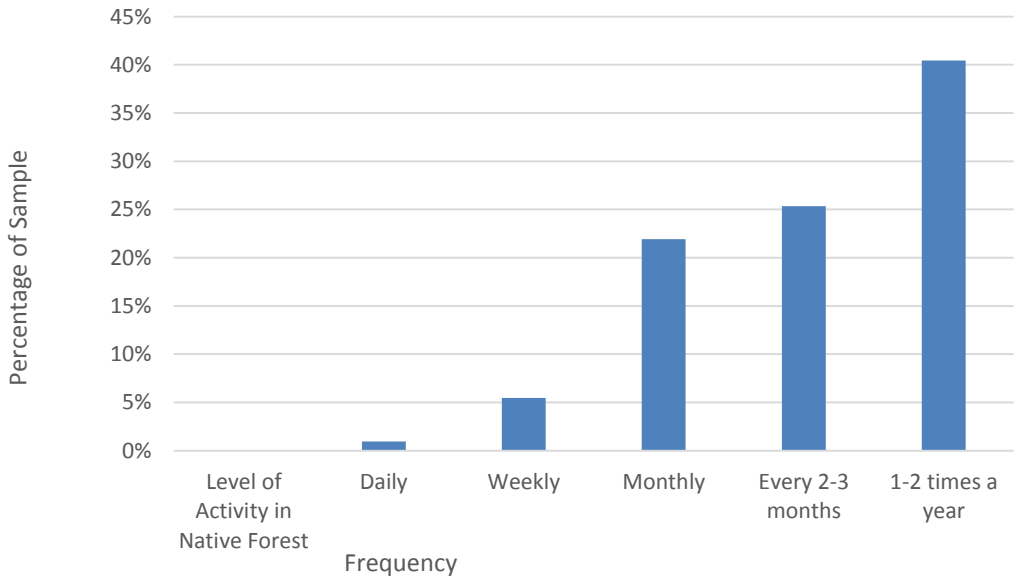


Figure 5. Frequency of participation



Cross-tabulation of Figures 4 and 5 reveals that fishing, tramping and employment activities are more likely to occur 1-2 times a year, while hunting is more likely to occur on a monthly basis (Table 4). Overall, this information suggests that although 59 per cent of respondents participate in forest based activities, the majority of these participants do so relatively infrequently.

Table 4. Cross-tabulation of activity and frequency

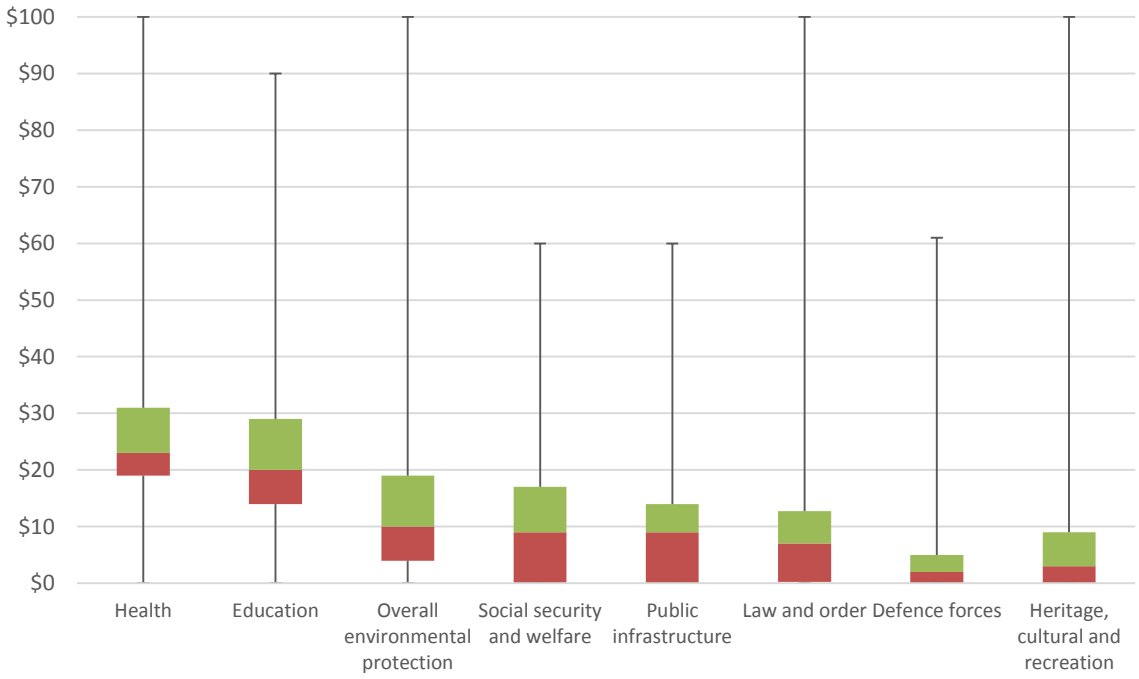
	Daily	Weekly	Monthly	Every 2-3 months	1-2 times a year	Rarely
Fishing	0.3%	1.2%	4.0%	4.9%	5.5%	0.9%
Hunting	0.3%	0.7%	2.5%	1.7%	1.8%	0.7%
Employment	0.2%	0.6%	0.7%	0.2%	1.1%	0.1%
Tramping	0.4%	2.5%	11.2%	11.5%	18.1%	2.6%
Other	0.0%	0.7%	2.6%	2.5%	4.0%	0.8%

3.2.3 Preferences for Allocating Public Expenditure

To explore how respondents viewed the relative importance of overall public environmental expenditure at the national level (relative to other possible public funding areas such as health or education) an expenditure allocation scenario was included in the survey that required respondents to allocate $100 representing all public spending across the eight major public expenditure categories as used in NZ Treasury reporting.

A ‘box and whisker’ plot (Fig. 6) in which the upper and lower ends of the ‘whiskers’ indicate the maximum and minimum values given in individual responses shows that some respondents allocated all the $100 to the health category, while other allocated nothing. The top of each ‘box’ shows the 75th percentile, while the bottom shows the 25th percentile. So for example, 75 per cent of respondents allocated at least $19 to health, and 25 per cent allocated more than $31. Where the green and red portions of a box meet is the median allocation, 50 per cent of respondents allocated less than $23, while 50 per cent allocated more than this.

Figure 6. Preferences for allocation of public expenditure



Overall preferences for spending allocation differed from current expenditure levels varied across categories (Fig. 6; Table 5). Respondents (on average) allocated far less to social security than current spending, slightly more or less to most other categories, but far more to health and environmental protection.

Table 5. Implied changes in public spending

	Current allocation %	New average allocation %	25% of respondents would allocate **LESS** than:	Median allocation %	25% of respondents would allocate **MORE** than:
Health	20	27	19	23	31
Education	19	21	14	20	29
Overall environmental protection	1	13	4	10	19
Social security and welfare	37	11	0	9	17
Public infrastructure	13	9	0	9	14
Law and order	5	9	0	7	13
Defense forces	2	4	0	2	5
Heritage, culture and recreation	3	6	0	3	9

3.3 Choice Modelling Results

The sample of 813 respondents, each completing six choice tasks, generated 4,878 choice observations used in statistical modeling. The parameter estimates presented in Table 6 are derived from an Error-component Random Parameter Logit specification. This type of model exemplifies an advanced contemporary approach that represents a relatively flexible form. Notably, the ability to allow parameter estimates to vary over respondents, rather than being held constant, reflects the degree of respondent heterogeneity in preferences over biodiversity attributes

When choosing their preferred option in each choice task, respondents may ignore some attributes, and base their decisions on those remaining. Following the choice tasks, respondents were asked to indicate which, if any, attributes they had ignored when selecting their preferred options. To account for this type of choice behaviour we have estimated what is commonly referred to as an attribute non-attendance model[4]. This accounts for respondents who ignore some attributes, by specifying in the model that these respondents, gained no benefit from certain attributes. Out of the 4,878 choice tasks completed, canopy tree species was ignored in 306 (6%) choice tasks; native invertebrates ignored in 432 (9%) choices; native birds ignored in 282 choices (6%); within-forest plants ignored in 372 (8%) choices; and tax contribution was ignored in 876 (18%) choices.

By conventional econometric standards the model performs well. All the TB-possum control attributes we characterised are highly statistically significant, meaning that they are important factors in resident's choice of management option. The model predicts how respondents choose a particular management option based on the outcomes and costs associated with that option. The parameter estimates tell us how an attribute relates to the overall utility of residents from the benefits of TBfree management in native forests. These weights indicate that respondents are more likely to choose a management option that has higher levels of protection for biodiversity outcomes, with changes in protection of canopy tree species having the largest influence, while they are less likely to choose options imposing greater tax contributions. Of the four main attributes, protection of forest canopies had by far the greatest utility weight, with protection of invertebrates having lowest utility.

[4] The approach adopted here takes advantage of the -888 coding available in Limdep™ software that assigns zero respondent utility to attributes coded in this way for each relevant respondent.

Table 6. Choice model parameter estimates

Attributes	Parameter estimates
Canopy tree species	2.01***[0.31]
Large native invertebrates	0.35***[0.05]
Native birds	0.72***[0.05]
Within-forest plants	0.50***[0.08]
Annual tax contribution	-0.99***[0.05]
No TBFree management option	-3.99***[0.73]
Provide habitat for native plants, birds and insects	1.01**[0.06]
Chi-squared [11d.f.]	3,369***
McFadden Pseudo R^2	0.32
Number of observations	4,878
Sample size	813

- ***, **,* denote statistical significance at the 1%, 5% and 10% levels respectively for the null hypothesis that a parameter estimate is not significantly different from zero.
- Standard errors in brackets.
- The standard deviations of normal distributions for the random variables are all significant at 1% level. Cost is treated as fixed.
- Model selection based on conventional econometric criteria: AIC, BIC, Likelihood Ratio tests, IID/IIA assumption rejected for MNL model.
- Model weighted to reflect population education distribution had no qualitative improvement.
- Model weighted to reflect population tramping distribution had no qualitative improvement[5].

The negative parameter estimated for the 'No TBfree management' option indicates a strong preference overall for TBfree management that avoids the poor outcomes associated with the 'No TBfree management' option. However, 109 respondents (13.4%) chose the 'No TBfree management' option at least once over the six choice tasks presented to them; 35 of these respondents chose this option only once, while 24 chose this option in all choice tasks. Generally, and unsurprisingly, the respondents who selected a zero expenditure for 'overall environmental protection' (Fig. 6) or (see below) indicated that they didn't see any value in contributing to TB-possum control benefits (Fig. 7) were more likely to choose the 'No TBfree management' option in the choice experiment.

To explore how willingness to pay for biodiversity outcomes might be influenced by the demographics, attitudes and beliefs of respondents (as assessed from their answers to the subsidiary questions in the survey), some interactions between variables in the model were tested[6]. We found no evidence of an interaction between high income and greater willingness

[5] SPARC 2007/08 Active NZ Survey (activenzsurvey.org.nz)
[6] Interactions estimated between demographic variables and attributes, and with an alternative specific constant (1 if no TBfree management option, 0 otherwise).

to pay. There was also no evidence of an effect of education, gender and employment status on willingness to pay.

We also explored how the responses in Table 3 (Importance of Native Forest Uses) affected willingness to pay, and, not surprisingly found for those respondents who indicated that native forests were very important to 'Provide habitat for native plants, birds and insects' were significantly more willing to pay (Table 6). No significant effects were found based on participation in forest based activities (Fig. 4).

Next we created variables representing those respondents that allocated nothing to the overall environmental category in Fig 6, and those respondents that allocated more than the current proportion of 1 per cent. No statistically significant effect was found on willingness to pay for biodiversity outcomes.

The proximity of a respondent to TBfree managed native forest could influence their preferences over biodiversity outcomes. Sometimes people value environmental improvements more if they live close to where they might occur. We tested for this spatial variability in preferences using TBfree managed forest location data presented in Fig 7. We tested for the amount of area of TBfree forest in a respondents region, and the distance to the nearest TBfree forest for each region, but found no significant effects on respondent preferences.

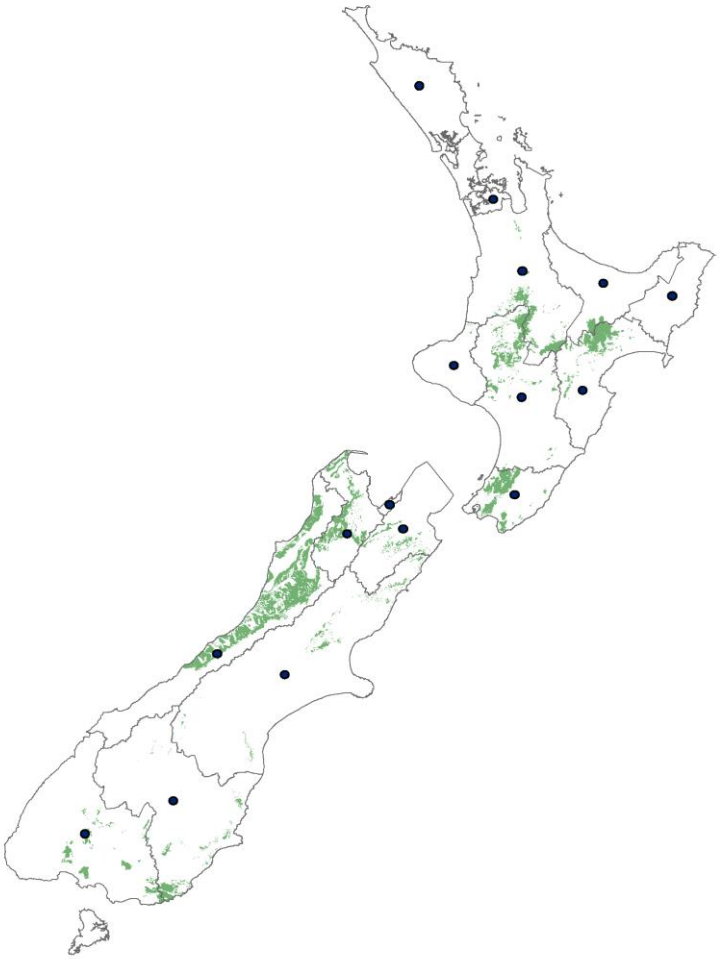


Figure 7. TBfree managed native forest by region with regional centroids

3.4 Monetary Value of Benefits

The model parameters in Table 6 are used to estimate the monetary value of benefits to the NZ public for biodiversity outcomes in TBfree NZ managed native forest. This is calculated as willingness to pay[7] (Table 7).

Table 7. Public willingness to pay for biodiversity outcomes in TBfree native forest

Forest attribute protected	Marginal WTP for each 1% increase in protection above DOC levels
Canopy tree species	$2.01 [$1.53-$2.50]
Large native invertebrates	$0.35 [$0.29-$0.42]
Native birds	$0.72 [$0.64-$0.79]
Within-forest plants	$0.50 [$0.37-$0.63]

95% Confidence Intervals in brackets. Values are per annum in 2013 dollars.

Applying the marginal WTP estimates in Table 7 to the levels of biodiversity outcomes from Table 1, the key messages are:

For conservation outcomes over and above the levels achieved by DOC, the average respondent was willing to pay (WTP);

- $2.01 for each 1% increase in the achievement of healthy unbrowsed forest canopies in TBfree NZ managed native forest[8].
- $0.72 for each 1% increase in protection of large native invertebrates in TBfree NZ managed native forest
- $0.50 for each 1% increase in protection of large native invertebrates in TBfree NZ managed native forest
- $0.35 for each 1% increase in protection of large native invertebrates in TBfree NZ managed native forest

[7] Willingness to pay is calculated as the ratio of a biodiversity attribute's estimated parameter to the tax-cost attribute parameter. The ratio captures the idea of a trade-off: how much tax would I be willing to exchange for biodiversity benefits?

[8] WTP for each attribute is estimated as linear. Non-linearity was tested using effects and dummy coding approaches with no qualitative improvement in modelling.

To value all the biodiversity improvements actually achieved from possum control, we combine the marginal WTP estimates with information about the efficacy of possum-only control to enhance biodiversity based on the type of forest, and the control method. The improvements in each biodiversity attribute, relevant to the 'no control' outcomes, vary depending on the type of forest where control occurs, and the control method used. To account for this in the valuation, we start by combining spatial data on 18 forest classes defined in the Forest Service Mapping Series 15[9], with spatial data on aerial and ground control application. Using the resulting spatial categorization, we assign a percentage improvement for each biodiversity attribute, to each area identified (2 control methods x 4 biodiversity attributes x 18 forest classes = 144 areas in total). The calculation process is illustrated with some exemplars in Fig. 8. The relevant proportion of forest area is multiplied by the percentage improvement to yield its weighted contribution to WTP. These values are then summed to arrive at the total percentage improvement for each attribute.

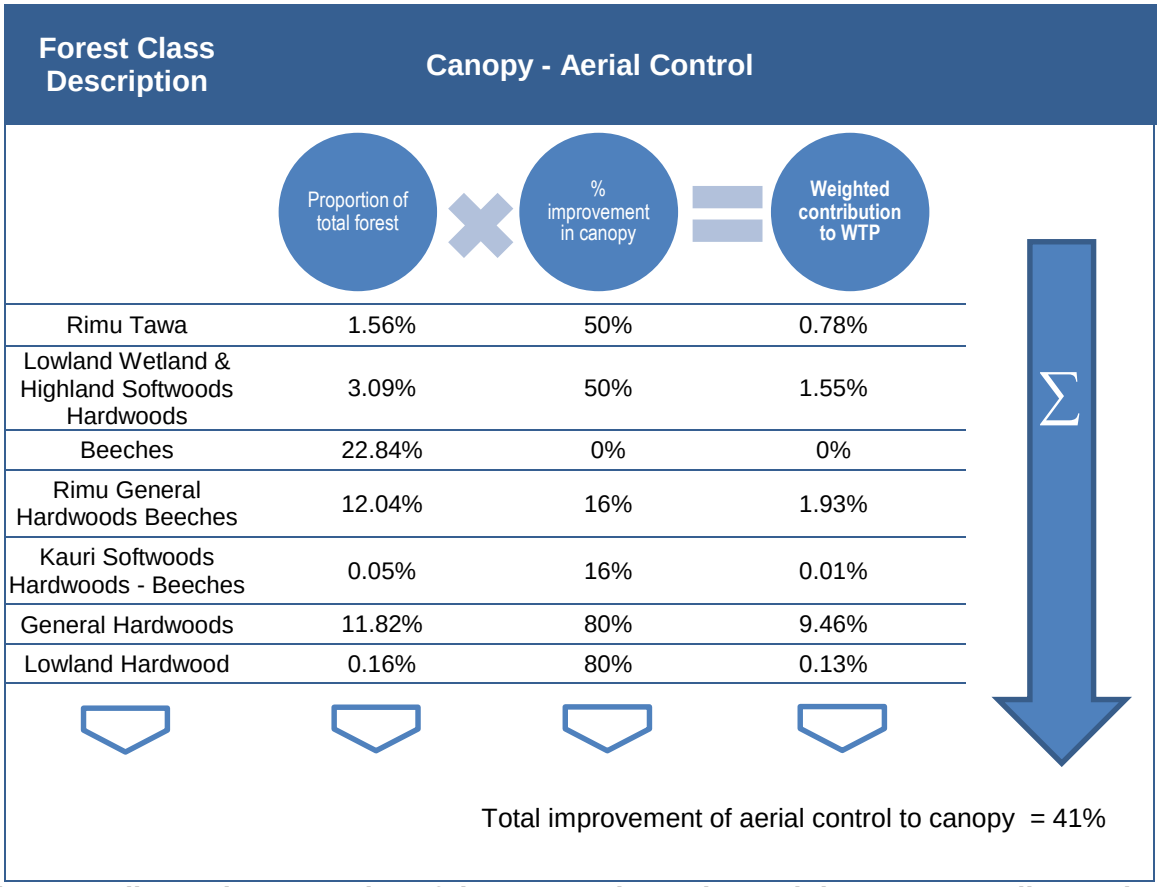


Figure 8. Illustrative examples of the approach used to weight WTP according to the likely effectiveness of possum control according for forest types. Note that the % improvement in canopy are relative to absolute size of the benefits delivered by DOC

The total percentage improvements for each attribute (Table 8) are then multiplied by marginal WTP (Table 7) to arrive at total benefit per person for each attribute, and in total (Table 8). This process results in WTP estimates that are weighted to reflect the extent of improvements for each forest type and control method combination.

[9] https://koordinates.com/layer/301-nz-fsms6-south-island/

Table 8. Per capita biodiversity benefits of possum control

	Canopy	Birds	Invertebrates	Plants	
Aerial control	41%	24%	24%	39%	
Ground control	14%	0%	0%	10%	
Marginal WTP	$2.01	$0.72	$0.50	$0.35	
Total benefit per person	$109.20	$17.16	$11.92	$17.33	**$155.62**

We use the per capita estimates to aggregate up to the national population level. To do so we must make a decision about the size of the population. The convention is to maintain consistency with the payment vehicle used in the choice model, which in this study was a change in personal tax levels. Therefore we use the number of individual tax payers with positive income at 2,773,911[10].

We must also decide how many of these individuals might have the same preferences as the respondents who were surveyed. An accepted approach is to use the response rate from the sampling process, which was 14.5% for this study. This assumes therefore, that only people interested in conservation responded, and that all non-respondents were not willing to pay for the TBfree NZ programme. It has been demonstrated that there are a variety of reasons why people do not answer surveys including time constraints, as well as genuine zero WTP[11]. Hence for evaluation we include comparison with an assumption that non-respondents have half the WTP of respondents, and that non-respondents have the same WTP of respondents[12] (Table 9).

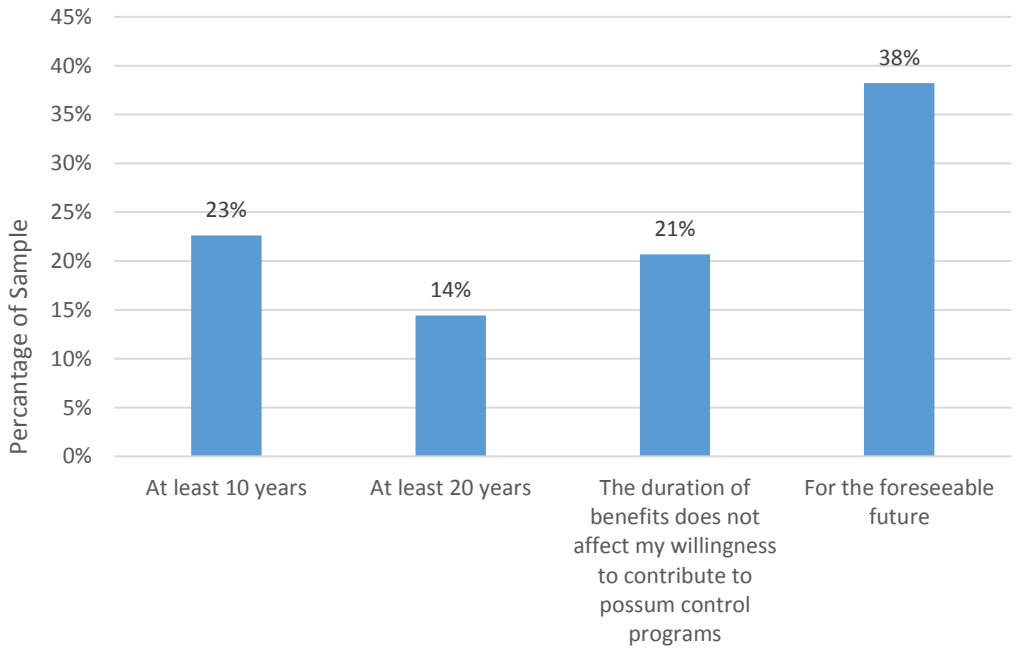
Table 9. Current NZ aggregate annual biodiversity benefits

Non-respondent benefits	Canopy	Birds	Invertebrates	Plants	Total
None	$46.5m	$7.3m	$5.1m	$7.4m	**$66.3m**
Half	$174.7m	$27.5m	$19.1m	$27.7m	**$248.9m**
All	$302.9m	$47.6m	$33.1m	$48.1m	**$431.7m**

[10] Statistics NZ Census, 2013.
[11] Morrison (2000). Aggregation biases in stated preference studies. Australian Economic Papers, 39:215-230.
[12] Mitchell and Carson (1989). Using survey to value public goods: the CVM approach. Washington, RFF.

Because TB-possum control in native forests may eventually cease if the disease is ever eradicated, we also explore whether the length of time that benefits were sustained affected respondents current willingness to pay for TBfree management (Fig 9).

Figure 9. Preferences for duration of benefits to ensure annual contribution



This implies that 79% of respondents were not WTP for benefits to native birds and invertebrates as improvements in these outcomes dissipate rapidly once control ceases, whereas canopy and plant benefits are assumed to endure for the foreseeable future (i.e.; one generation, >25 years). Adjusting for this effect results in lower estimates (Table 10) and a conservative annual benefit in the order of $56.4million.

Table 10. Current NZ aggregate annual biodiversity benefit accounting for effect duration preferences

Non-respondent benefits	Canopy	Birds	Invertebrates	Plants	Total
None	$46.5m	$1.5m	$1.1m	$7.4m	**$56.4m**
Half	$174.7m	$5.5m	$3.8m	$27.7m	**$211.7m**
All	$302.9m	$9.5m	$6.6m	$48.1m	**$367.1m**

The estimates in Table 9 tell us what one year's benefits are worth currently. To estimate Present Values (PV) for future flows of benefits requires several assumptions including:

- The extent to which control activities are ongoing or cease straightaway.
- The length of time that benefits are sustained post control. This is the length of time that possum densities remain below a threshold of significant damage.
- The length of time over which significant deterioration occurs. This is the length of time in which possum numbers recovery until all benefits are undone.
- The discount rate applied to future values.

Using this information we graph the PV of flows of benefits for each biodiversity outcome (Appendix A) based on assumptions regarding the ongoing control period, the period of stable benefits, and the period of benefit deterioration relevant to each attribute (for a discount rate of 8%[13]), for each of the three non-respondent benefit assumptions (none, half, all). We find that the PV of flows of benefits is largest for native forest canopy outcomes (Table 11). Marginal WTP is highest for this attribute but equally significant is the considerably long time period over which benefits are stable before possum density reaches a threshold for significant damage. This contrasts with the native bird and invertebrate benefits that rapidly deteriorate once control ceases. The estimates for birds and invertebrates under control cessation are only about 20% of those derived from ongoing control. The flow of total benefits (Fig. 10) reflects this influence, revealing that most of the benefits accrue over the first half of the flow of benefits while control is ongoing.

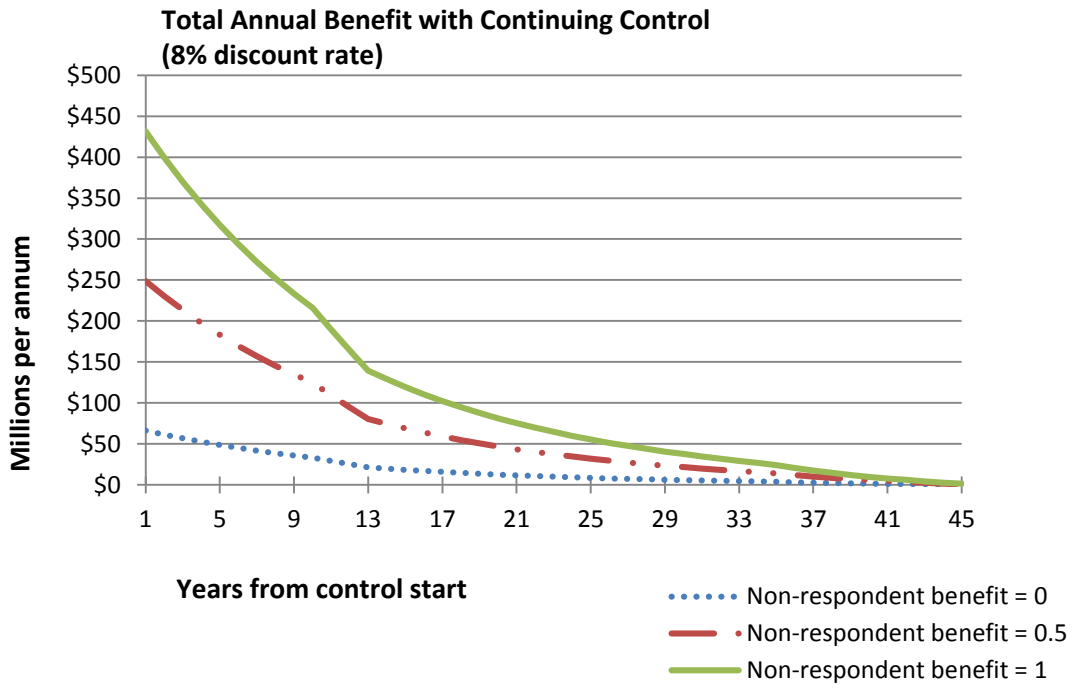
Table 11 Present value of NZ aggregate biodiversity benefits

Biodiversity Attribute	Non-respondent benefits	Continued NPMP control			Ceased control		
		None	Half	All	None	Half	All
Canopy		$600m	$2,254m	$3,907m	$539m	$2,024m	$3,510m
Birds		$57m	$213m	$369	$11m	$41m	$71m
Invertebrates		$39m	$148m	$256m	$8m	$29m	$50m
Plants		$93m	$349m	$604m	$79m	$296m	$514m

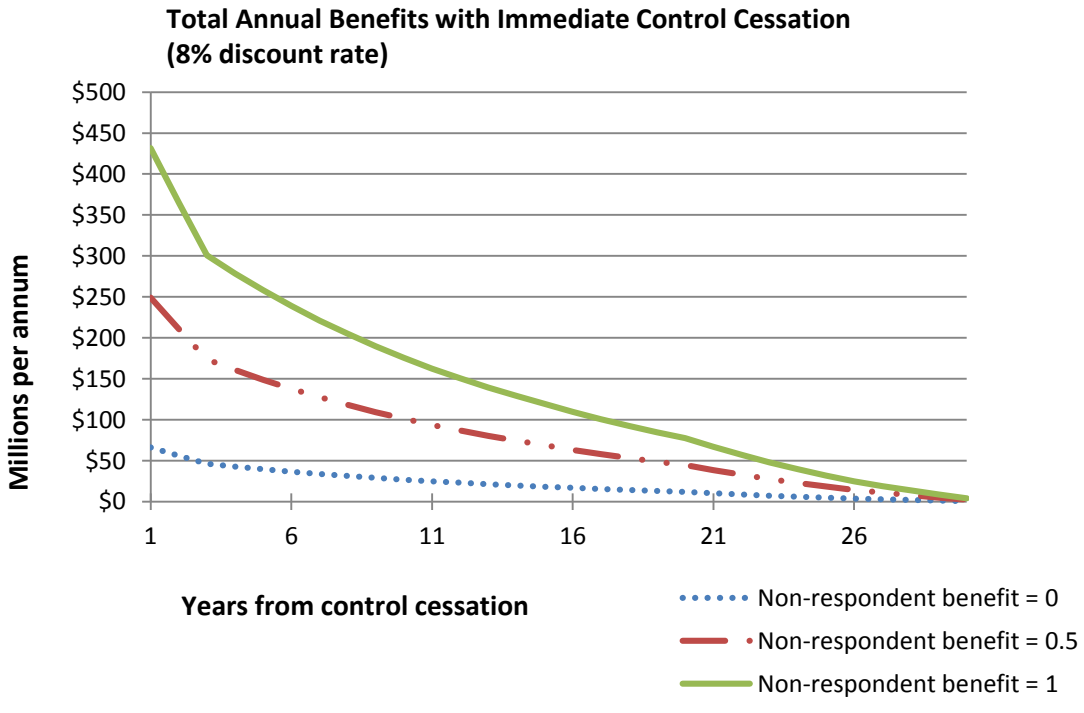
[13] NZ Treasury recommended rate.

Figure 10. Future flows of total biodiversity benefits

Total benefits with **continuing** action



Total benefits with **cessation** of control straightaway



The PV of the flow of total benefits (Fig. 10), when applying the most conservative assumptions used here, is in the order of $621.4 million (Table 12). This estimate assumes: only 14.5% of the NZ public have positive WTP for the biodiversity outcomes valued in the survey; an 8% discount rate that can be considered to reflect an upper range of appropriate rates for public projects; and that 80% of the NZ public that do have positive WTP, are unwilling to contribute to control that does not achieve long-term outcomes.

The choice of appropriate discount rate can be an important consideration when calculating PV. The discount rate chosen by *private* individuals should reflect the return available on alternative *investments*. Although in practice this might be difficult, from a theoretical point of view a firms opportunity cost of funds yields the correct discount rate. The before tax rate of return measures the value of output that the funds would have generated for society. There is less consensus on the conceptually appropriate discount rate for *government* projects. Unlike in the case of private investment, some of the funds for the government project will come at the cost of *consumption* as well as investment. The opportunity cost of funds that come at the cost of consumption can be measured by the after tax rate of return on savings. If we knew the proportion of project costs sourced from consumption and from investment, a weighting of consumption and investment rates could be formed. This is impractical but we expect the appropriate discount rate for public projects to fall in the range starting from the post-tax rate of return, and going up to the pre-tax rate of return. We interpret 4% and 8% discount rates as spanning that range. Applying the lower discount rate of 4% leads to significantly higher total PV (Table 12).

Table 12. Present Value of total benefit flows

		Non-respondent benefits		
	Control status	None	Half	All
PV: 8% discount rate	Ongoing	$788.4m	$2,962.1m	$5,135.8m
	Cease	$636.3m	$2,390.5m	$4,144.7m
PV: 4% discount rate	Ongoing	$1,219.7m	$4,582.4m	$7,945.2m
	Cease	$882.4m	$3,315.1m	$5,747.9m
PV: 8% discount rate Adjusted for benefit duration preferences	Ongoing	$711.7m	$2,673.8m	$4,635.8m
	Cease	$621.4m	$2,334.7m	$4,047.9m

4 Conclusions

The economic values estimated here indicate that at least some New Zealanders place a very high value on the biodiversity within native forest, which is consistent with other research conducted by TBfree NZ and others. It is important to note that value can be much higher than cost – the willingness to pay estimates are a measure of the maximum benefit accruing to individuals and therefore is the most they would pay, but they would prefer to pay much less if that were possible.

We acknowledge that the attributes we chose, and the way we characterised changes in them in response to pest management are simplistic. We considered it impractical to fully depict the true level of complexity in our attribute descriptions and conservation outcomes, in the belief that would have made them far more difficult for respondents to comprehend and evaluate. It is therefore important to assess the extent to which TB-possum management is likely to have delivered the simple biological outcomes we portrayed.

For TB-possum control, a key finding is that respondents placed higher value on protection of forest canopies than on the other three attributes. Because canopy protection (i) is an almost exclusively possum-specific problem; (ii) can be achieved with even moderate levels of possum control, and (iii) is a benefit that is likely to last for many decades, TB-possum control can be confidently argued to provide a high level of benefit in relation to this attribute.

The WTP results found here are consistent with those of comparable choice modelling studies, finding significant public support for protection of native forests, and the flora and fauna contained within[14] [15]. Public WTP for increases in Spanish native forest has been valued at €1.4 per 1% increase[16], which is comparable to the WTP per 1% of native tree canopy protection found by this study. Similarly, regeneration of deteriorated forest in Poland has been valued at €0.4 per 1% increase in area of forest regenerated[17]; and WTP for increases in forest conservation areas in Finland[18] has been estimated at €4 per 1% increase in area. Relevant New Zealand studies have estimated significant public WTP for protection of native forest[19]. Including WTP for increases in birds and insects from few to many ($122 and $94) in Nelson Lakes Beech forest[20]; and an estimate of $0.64 for the presence of each additional bird species in Abel Tasman National Park[21]. In a plantation forest context, WTP for an increase from 0.5% to 10% of forests where Kiwi calls are heard has been estimated at $28[22]. Although these comparisons vary over research contexts and design elements, they do reveal that the WTP estimates found in this study are in the range of those found by researchers internationally and domestically.

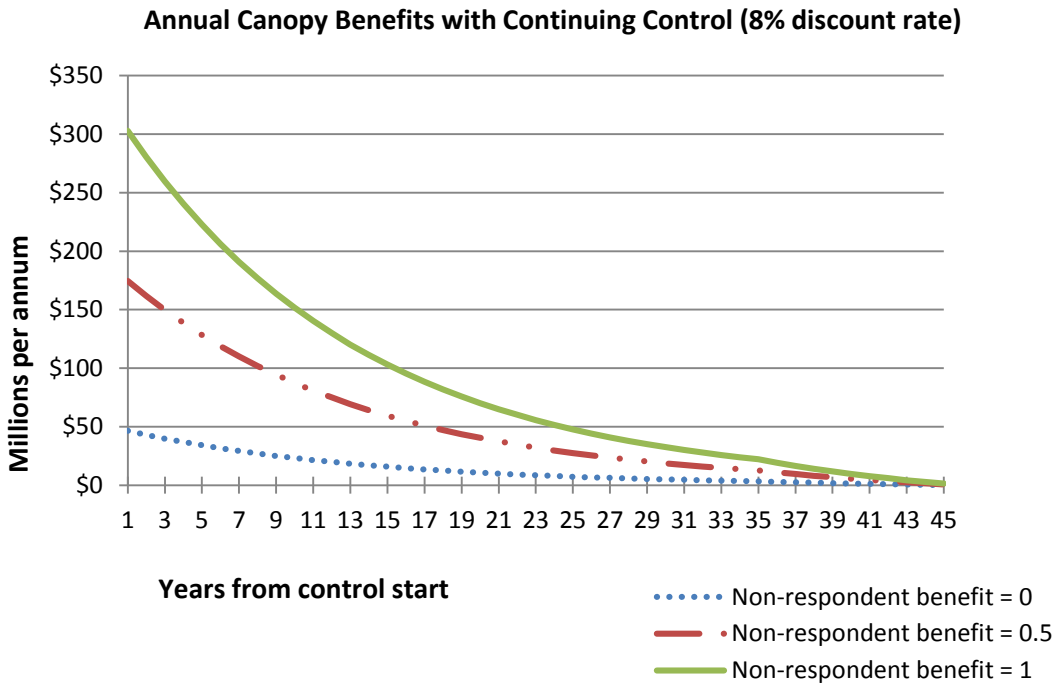
[14] Vecchiato D. Tempesta T. 2013. Valuing the benefits of an afforestation project in a peri-urban area with choice experiments. Forest Policy and Economics 26:111–120.
[15] Czajkowski M. Bartczak A. Giergiczny M. Navrud S. Żylicza T. 2014. Providing preference-based support for forest ecosystem service management. Forest Policy and Economics 39:1-12.
[16] Hoyos D. Mariel P. Pascual U. and Etxano I. 2012. Valuing a Natura 2000 network site to inform land use options using a discrete choice experiment: An illustration from the Basque Country. Journal of Forest Economics 18:329–344.
[17] Czajkowski M. Buszko-Briggs M. and Hanley N. 2009. Valuing changes in forest biodiversity. Ecological Economics 68:2910-2917.
[18] Lehtonen E. Kuuluvainen J. Pouta E. Rekola M. Li C-Z. 2003. Non-market benefits of forest conservation in southern Finland. Environmental Science and Policy 6:195-204.
[19] Kerr G.N. and Cullen R. (1995). Public preferences and efficient allocation of a possum-control budget. Journal of Environmental Management 43:1-15.
[20] Kerr G.N. and Sharp B.M.H. (2008). Biodiversity management: Lake Rotoiti choice modelling study. AERU Research Report No. 310.
[21] Lee P. Cassells S. and Holland J. (2013). The non-market value of Abel Tasman National Park, New Zealand: A choice modelling application. Contributed paper prepared for presentation at the 57th AARES Annual Conference, Sydney, 5th-8th February.
[22] Yao R.T, Scarpa R. Turner J.A. Barnard T.D. Rose J.M. Palma J.H.N. and Harrison, D.R. (2014). Valuing biodiversity enhancement in New Zealand's planted forests: Socioeconomic and spatial determinants of willingness-to-pay. Ecological Economics, 98, 90–101.

Overall, the high proportion of WTP relating to respondents' desire to protect native forest as a whole indicates that their WTP is likely to have equated to many tens of millions of dollars. Adding to that, our assumption that (effectively) 85% of New Zealander's would not pay anything for the conservation benefits of TB-possum control appears likely to be extremely conservative, given that only 4% of respondents indicated no interest in contributing to the conservation benefits. If so, our national WTP estimates will also be conservative.

Appendix A: Present Value Graphs

Figure 11. Present Value of future canopy benefits

15 years **continuing** action
20 years stable benefits
10 years of decline to zero benefits in year 45
PV = $599.7m; $2,253.8m; $3,906.6m



Cease control activities straightaway
20 years stable benefits
10 years of decline to zero benefits in year 30
PV = $538.8m; $2,024.3m; $3,509.8m

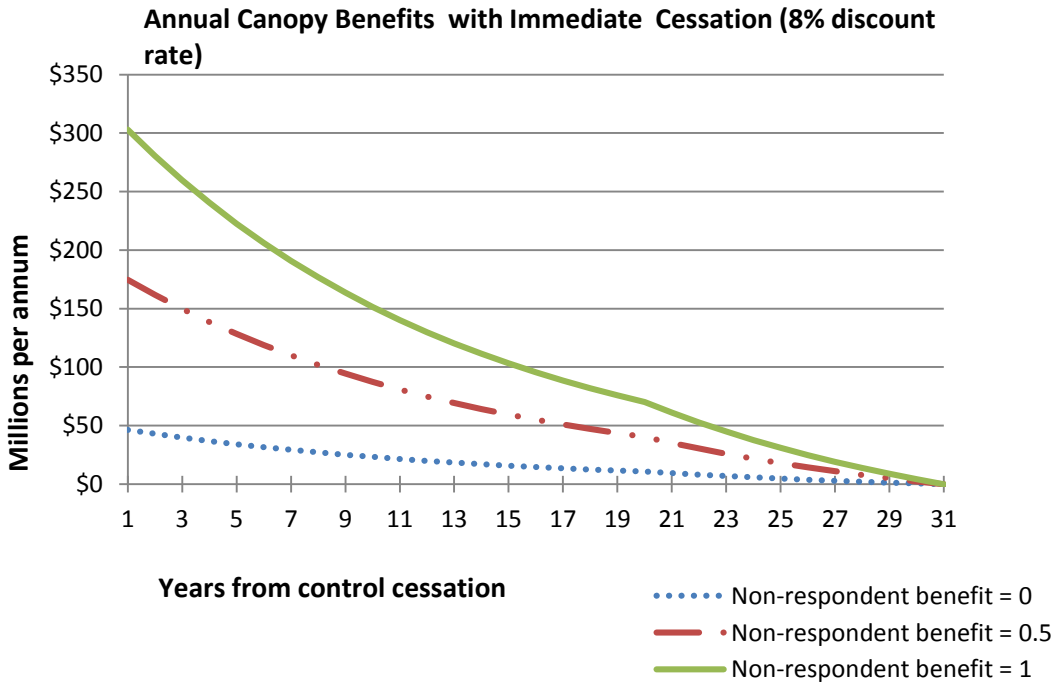
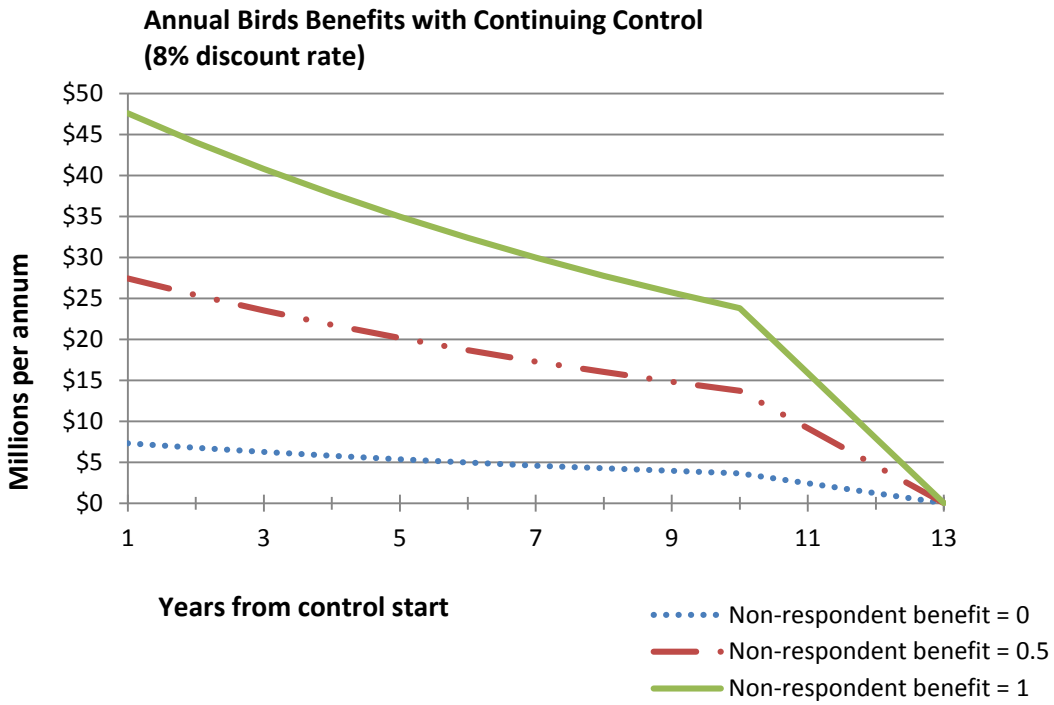


Figure 12. Present Value of future bird benefits

10 years **continuing** action
1 year stable benefits
1 years of decline to zero benefits in year 13
PV = $56.6m; $212.7m; $368.8m



Cease control straightaway
1 year stable benefits
1 years of decline to zero benefits in year 3
PV = $10.9m; $41.2m; $71.4m

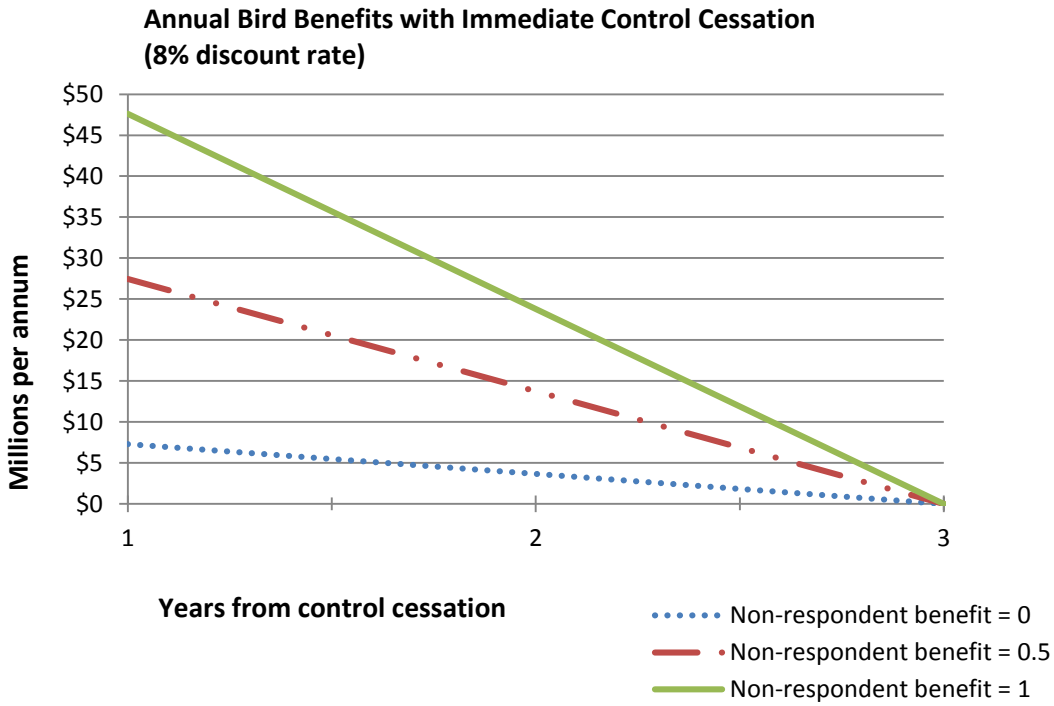
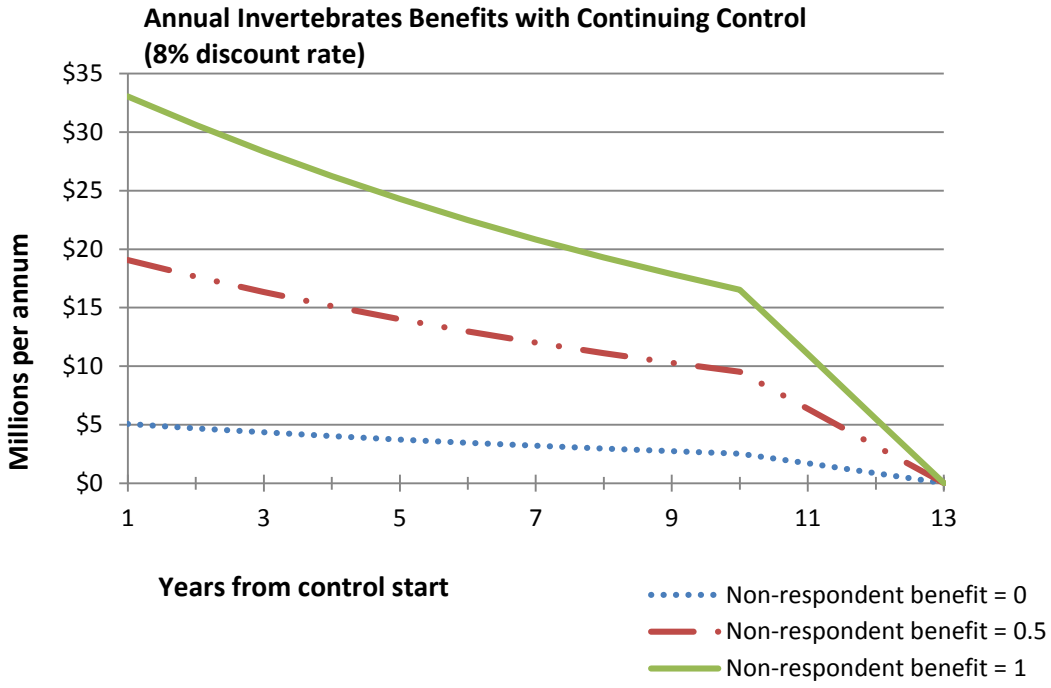


Figure 13. Present Value of future invertebrate benefits

10 years **continuing** action
1 year stable benefits
1 years of decline to zero benefits ~~in~~ by year 13
PV = $39.3m; $147.7m; $256.1m



Cease control straightaway
1 year stable benefits
1 years of decline to zero benefits in year 3
PV = $7.6; $28.6m; $49.6m

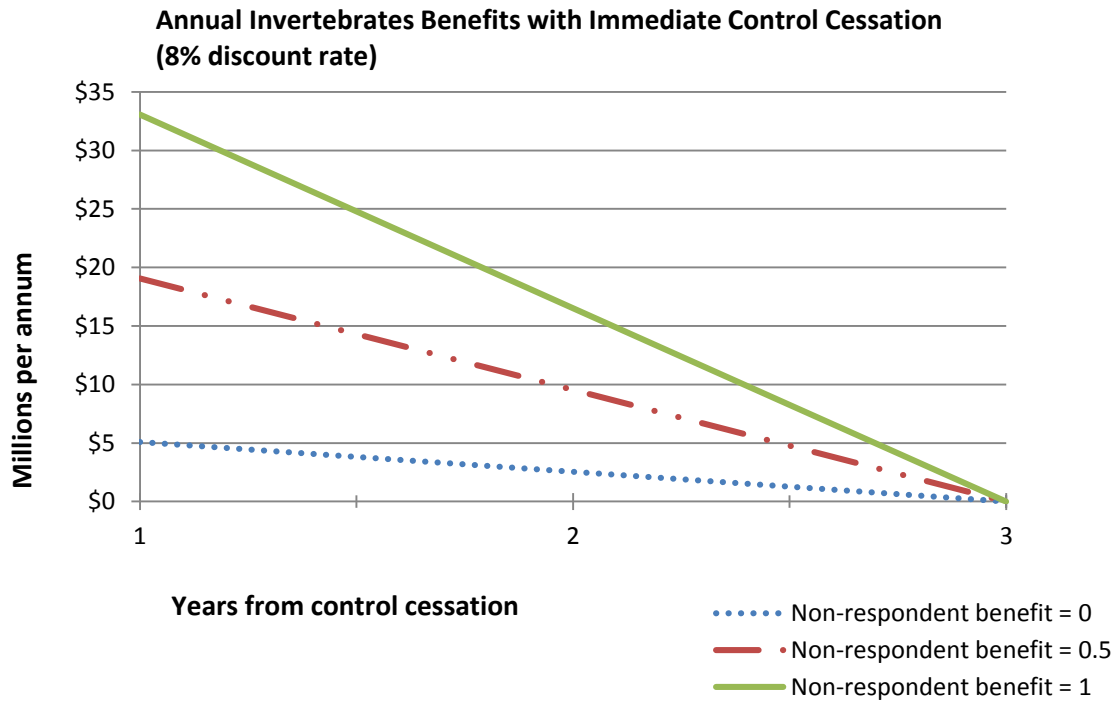
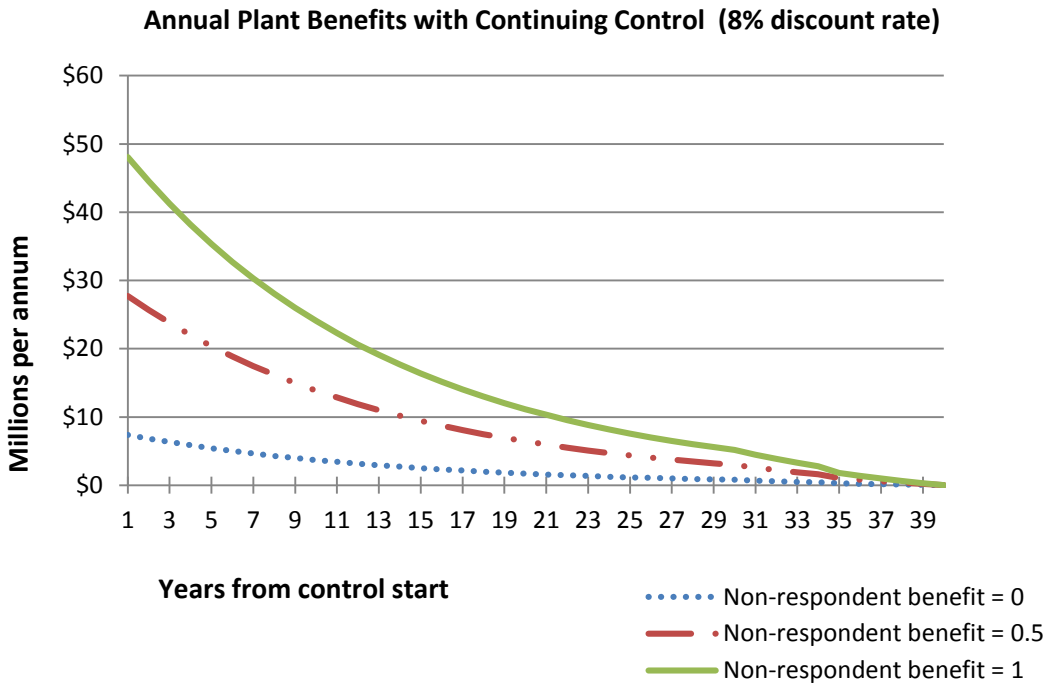
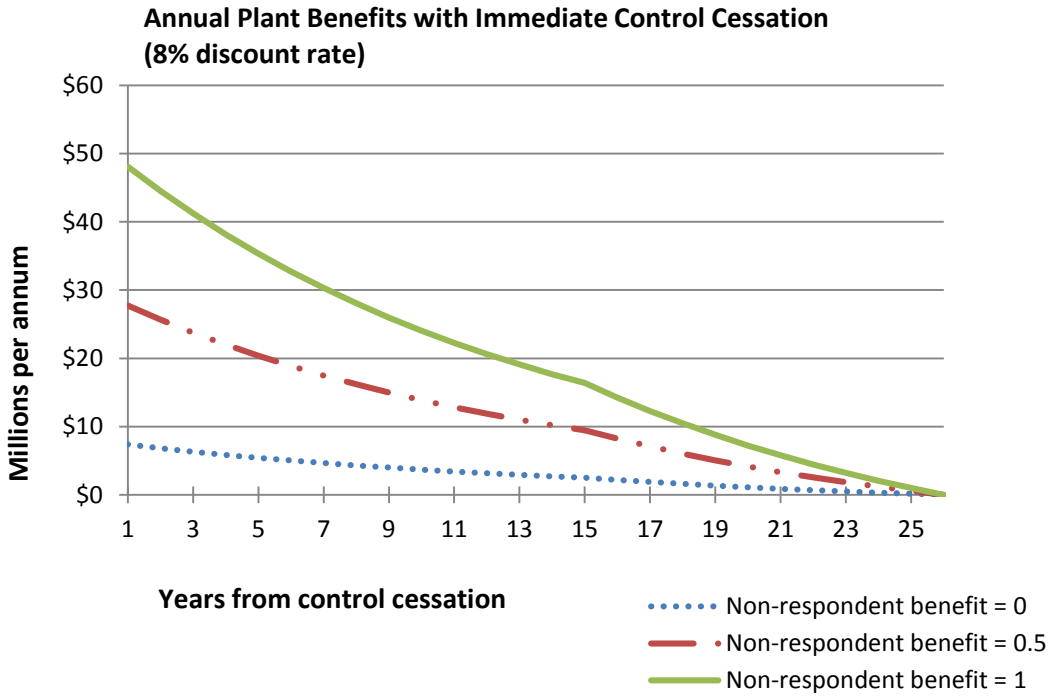


Figure 14. Present Value of future plant benefits

15 years **continuing** action
15 years stable benefits
10 years of decline to zero benefits in year 40
PV = $92.8m; $348.5m; $604.2m



Cease control straightaway
15 years stable benefits
10 years of decline to zero benefits in year 25
PV = $78.9m; $296.4m; $513.9m



Appendix B: Public Survey

Biodiversity benefits of possum control in native forests

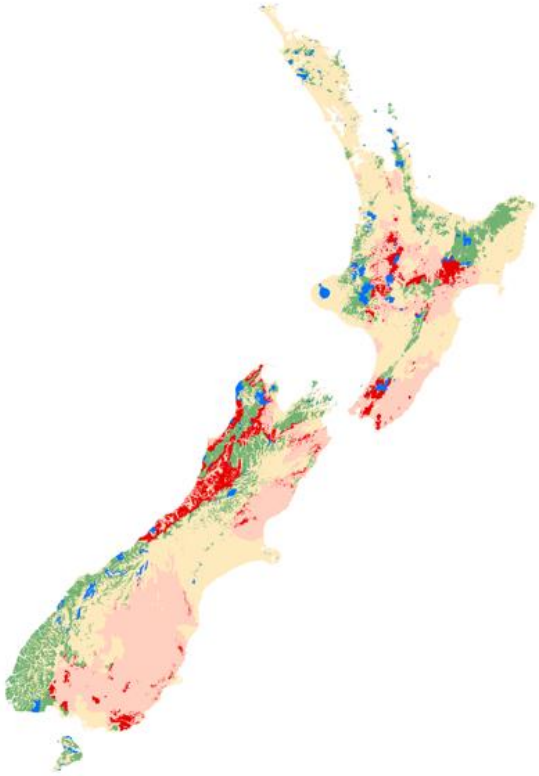
You are invited to participate in a survey assessing whether New Zealanders value the conservation outcomes in native forests where TBfree New Zealand (TBfree) carries out possum control. We want to know your views as this will help to manage native forests in the way New Zealanders think is best.

Native forests cover almost a quarter of New Zealand. They provide many benefits, including recreational, cultural and economic. They are particularly important for conservation, because they provide a large amount of habitat for native plants and animals that has been only moderately affected by humans. However, even in such little modified native forests, introduced pests such as possums, rats and stoats pose major threats to the survival of some native species.

The Department of Conservation (and regional councils and community groups) therefore carry out pest control in many areas, to mitigate some of the most undesirable effects they have on native plants and animals. This includes extensive control of introduced possums. However, the number of pests and the very large areas they affect mean that current funding levels are only sufficient to cover some of the problems in some of the area.

TBfree also carries out extensive control of possums in areas where they are infected with Bovine TB. By reducing infected possum populations to very low densities and maintaining them at very low densities for approximately 10 years, with no immigration of TB-infected possums into these areas, the disease can be eradicated from wildlife. TB is a disease that can affect humans. Wild possums can carry TB and pass it on to farmed cattle and deer.

In extensive native forest, TBfree's control programme not only controls possums but also rats and stoats. Although conducted for TB-control purposes, control of TB-infected possum populations also reduces their impacts on native plants and animals. The map below shows the areas where TBfree and DOC operate pest management in native forest in New Zealand. Some of these areas contain national parks such as Kahurangi and Paparoa on the West Coast of the South Island, and Tongariro in the central North Island.



Key: Areas shaded green are native forest.
Areas shaded blue are native forests where DOC carries out pest management.
Areas shaded red are native forest where TBfree NZ carries out pest management.
Areas shaded pink are the total areas where TBfree NZ conducts TB management.

The focus of this survey is on the benefits to native forests generated by TBfree NZ in the red areas.

It would be appreciated if you would complete this questionnaire, even if you think you don't know much about environmental management. We need answers from all types of people to ensure we are representing the views of most residents. There are no wrong or right answers.

The questionnaire is anonymous, and you will not be identified as a respondent without your consent. You may at any time withdraw your participation, including withdrawal of any information you have provided. If you complete the questionnaire, however, it will be understood that you have consented to participate in the project and consent to publication of the results of the project with the understanding that anonymity will be preserved.

The survey is being conducted by researchers at Lincoln University and Landcare Research Ltd. The survey has been read and approved by the Lincoln University Human Ethics Committee. Dr Peter Tait and Professor Caroline Saunders of Lincoln University are available to answer any questions or concerns about the research, please contact them at:

Caroline Saunders	Peter Tait
+64 3 423 0382	+64 3 423 0384
caroline.saunders@lincoln.ac.nz	peter.tait@lincoln.ac.nz

1. Which region do you usually live in? (Q1-4 are set up as quotas following SNZ Census 2013)

- ❍ Auckland
- ❍ Bay of Plenty
- ❍ Canterbury
- ❍ Gisborne
- ❍ Hawke's Bay
- ❍ Manawatu-Wanganui
- ❍ Marlborough
- ❍ Nelson
- ❍ Northland
- ❍ Otago
- ❍ Southland
- ❍ Taranaki
- ❍ Tasman
- ❍ Waikato
- ❍ Wellington
- ❍ West Coast

2. Are you

- ❍ Male
- ❍ Female

3. What is your Age?

- ❍ 18 - 24 years old
- ❍ 25 - 34 years old
- ❍ 35 - 44 years old
- ❍ 45 - 54 years old
- ❍ 55 - 64 years old
- ❍ 65 years old or more

4. Please indicate your household yearly income from all sources before tax.

- ❍ Loss
- ❍ $0 to $20,000
- ❍ $20,001 to $40,000
- ❍ $40,001 to $50,000
- ❍ $50,001 to $70,000
- ❍ $70,001 to $100,000
- ❍ $100,001 or more

5. What do you think are the most important aspects of native forests in New Zealand?

Please select the relevant circle that best describes how important each aspect is to you.

	Very Important 1	2	3	4	Not important 5	Don't know
Attracting tourists	❍	❍	❍	❍	❍	❍
Fishing	❍	❍	❍	❍	❍	❍
Hunting	❍	❍	❍	❍	❍	❍
Tramping	❍	❍	❍	❍	❍	❍
Providing employment opportunities	❍	❍	❍	❍	❍	❍
Preserving cultural and heritage values	❍	❍	❍	❍	❍	❍
Preserving fresh water quality in rivers and lakes	❍	❍	❍	❍	❍	❍
Encouraging commercial enterprises	❍	❍	❍	❍	❍	❍
Enhancing New Zealand’s international brand	❍	❍	❍	❍	❍	❍
Providing recreational opportunities	❍	❍	❍	❍	❍	❍
Preserve resources for future generations	❍	❍	❍	❍	❍	❍
Provide habitat for native plants, birds and insects	❍	❍	❍	❍	❍	❍

6. What activities do you undertake in native forests? (Select as many as applicable)

- ❑ Tramping
- ❑ Hunting
- ❑ Fishing
- ❑ Employment
- ❑ Other (please specify) _____
- ❑ None

7. How often would best describe your level of activity in native forests?

- ❍ Daily
- ❍ Weekly
- ❍ Monthly
- ❍ Every 2-3 months
- ❍ 1-2 times a year
- ❍ Rarely/never

Background Information for Comparing Management Options

The next set of questions asks you to make choices between three possible options. Each option presents different outcomes for some environmental features of native forests that could occur with different levels of management effort by TBfree NZ.

Each option is described in terms of four environmental features of native forests that are vulnerable to possum, rat and stoat damage:

1. Impacts on forest canopy through damage to **possum preferred tree species** such as

Kamahi, Rata, Totara and others

Native forest canopy

Totara Kamahi Rata

Possum preferred species

2. Impacts on **large native invertebrates** vulnerable to possum predation such as Giant

Snails and Weta

Giant Snail Weta

3. Impacts on **native birds** vulnerable to possum predation or competition for food such as Kokako, Tui, Bellbird and Kereru

Kokako Tui Bellbird Kereru

4. Impacts on **within-forest native plants** such as tree fuchsia, mistletoe and others

Tree fuchsia Mistletoe

In the following questions, changes in each native forest feature are described by the impacts of possums, rats and stoats **in the forests that TBfree manages**, and also by the **increased level of effective protection provided by TBfree efforts**, relative to that

currently undertaken by DOC.

Depending upon the option selected, this may require a contribution that the community would have to provide to ensure it is achieved. It is assumed that this contribution would be via an annual contribution in personal taxes. This provides a means of assessing the actual value that you consider improvement to native forests and bird life is worth. Remember that any additional improvements require expenditure within the budget you face.

Whilst the options presented may not be identical to your views, it is important that you select the one that most closely resembles your view. This will ensure that as far as practical your selected view will be considered alongside others. In this way, it will help us to build a picture of the value that the community paces on alternative control options.

There are no trick questions or correct/incorrect answers – we are just trying to understand the value to the community of various options.

For each of the following questions please select the option you prefer the most.

Set 1 of 6

Each *column* describes a management option. Which of the following management options would you prefer? Select your choice and click on **>>** below.

	No TBfree management	TBfree management option	TBfree management option
Canopy tree species	 **Heavy browse and dieback** of vulnerable canopy species No increase in protection above DOC level	 **Most** Tbfree managed forest with healthy unbrowsed canopies **140%** increase in protection above DOC level	 **Most** Tbfree managed forest with healthy unbrowsed canopies **140%** increase in protection above DOC level
Large native invertebrates	 All large native invertebrate populations **severely affected** No increase in protection above DOC level	 **Most** possum-and rat-vulnerable large invertebrates well protected but a few still affected **120%** increase in protection above DOC level	 **Some** possum-vulnerable large invertebrates partially protected but most still affected **20%** increase in protection above DOC level
Native birds	 All possum-vulnerable native birds **severely affected** No increase in protection above DOC level	 **Some** possum-vulnerable native birds partially protected **25%** increase in protection above DOC level	 **Most** possum-vulnerable native birds protected **100%** increase in protection above DOC level
Within-forest plants	 All within-forest plants **heavily defoliated** No increase in protection above DOC level	 **Some** but not all vulnerable within-forest plants protected **100%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed within-forest plants **150%** increase in protection above DOC level
Annual tax contribution	$0	$75	$50

Selection				>>

Set 2 of 6

Each *column* describes a management option. Which of the following management options would you prefer? Select your choice and click on **>>** below.

	No TBfree management	**TBfree management option**	**TBfree management option**
Canopy tree species	 **Heavy browse and dieback** of vulnerable canopy species No increase in protection above DOC level	 **Most** Tbfree managed forest with healthy unbrowsed canopies **140%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed canopies **150%** increase in protection above DOC level
Large native invertebrates	 All large native invertebrate populations **severely affected** No increase in protection above DOC level	 **Most** possum-and rat-vulnerable large invertebrates well protected but a few still affected **120%** increase in protection above DOC level	 **Most** possum-and rat-vulnerable large invertebrates well protected but a few still affected **120%** increase in protection above DOC level
Native birds	 All possum-vulnerable native birds **severely affected** No increase in protection above DOC level	 **Some** possum-vulnerable native birds partially protected **25%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy native bird populations **150%** increase in protection above DOC level
Within-forest plants	 All within-forest plants **heavily defoliated** No increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed within-forest plants **150%** increase in protection above DOC level	 **Some** but not all vulnerable within-forest plants protected **100%** increase in protection above DOC level
Annual tax contribution	$0	$75	$50

Selection				>>

Set 3 of 6

Each *column* describes a management option. Which of the following management options would you prefer? Select your choice and click on **>>** below.

	No TBfree management	TBfree management option	TBfree management option
Canopy tree species	 **Heavy browse and dieback** of vulnerable canopy species No increase in protection above DOC level	 **Most** Tbfree managed forest with healthy unbrowsed canopies **140%** increase in protection above DOC level	 **Most** Tbfree managed forest with healthy unbrowsed canopies **140%** increase in protection above DOC level
Large native invertebrates	 All large native invertebrate populations **severely affected** No increase in protection above DOC level	 **Most** possum-and rat-vulnerable large invertebrates well protected but a few still affected **120%** increase in protection above DOC level	 **Most** possum-and rat-vulnerable large invertebrates well protected but a few still affected **120%** increase in protection above DOC level
Native birds	 All possum-vulnerable native birds **severely affected** No increase in protection above DOC level	 **All** Tbfree managed forest with healthy native bird populations **150%** increase in protection above DOC level	 **Some** possum-vulnerable native birds partially protected **25%** increase in protection above DOC level
Within-forest plants	 All within-forest plants **heavily defoliated** No increase in protection above DOC level	 **Some** but not all vulnerable within-forest plants protected **100%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed within-forest plants **150%** increase in protection above DOC level
Annual tax contribution	$0	$50	$75
Selection			

Set 4 of 6

Each *column* describes a management option. Which of the following management options would you prefer? Select your choice and click on **>>** below.

	No TBfree management	**TBfree management option**	**TBfree management option**
Canopy tree species	 **Heavy browse and dieback** of vulnerable canopy species No increase in protection above DOC level	 **Most** Tbfree managed forest with healthy unbrowsed canopies **140%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed canopies **150%** increase in protection above DOC level
Large native invertebrates	 All large native invertebrate populations **severely affected** No increase in protection above DOC level	 **All** large invertebrates protected **150%** increase in protection above DOC level	 **Some** possum-vulnerable large invertebrates partially protected but most still affected **20%** increase in protection above DOC level
Native birds	 All possum-vulnerable native birds **severely affected** No increase in protection above DOC level	 **Most** possum-vulnerable native birds protected **100%** increase in protection above DOC level	 **Most** possum-vulnerable native birds protected **100%** increase in protection above DOC level
Within-forest plants	 All within-forest plants **heavily defoliated** No increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed within-forest plants **150%** increase in protection above DOC level	 **Some** but not all vulnerable within-forest plants protected **100%** increase in protection above DOC level
Annual tax contribution	$0	$100	$25

Selection				>>

Set 5 of 6

Each *column* describes a management option. Which of the following management options would you prefer? Select your choice and click on **>>** below.

	No TBfree management	**TBfree management option**	**TBfree management option**
Canopy tree species	 **Heavy browse and dieback** of vulnerable canopy species No increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed canopies **150%** increase in protection above DOC level	 **Most** Tbfree managed forest with healthy unbrowsed canopies **140%** increase in protection above DOC level
Large native invertebrates	 All large native invertebrate populations **severely affected** No increase in protection above DOC level	 **All** large invertebrates protected **150%** increase in protection above DOC level	 **Most** possum-and rat-vulnerable large invertebrates well protected but a few still affected **120%** increase in protection above DOC level
Native birds	 All possum-vulnerable native birds **severely affected** No increase in protection above DOC level	 **Some** possum-vulnerable native birds partially protected **25%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy native bird populations **150%** increase in protection above DOC level
Within-forest plants	 All within-forest plants **heavily defoliated** No increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed within-forest plants **150%** increase in protection above DOC level	 **Some** but not all vulnerable within-forest plants protected **100%** increase in protection above DOC level
Annual tax contribution	$0	$50	$75

Selection				>>

Set 6 of 6

Each *column* describes a management option. Which of the following management options would you prefer? Select your choice and click on **>>** below.

	No TBfree management	TBfree management option	TBfree management option
Canopy tree species	 **Heavy browse and dieback** of vulnerable canopy species No increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed canopies **150%** increase in protection above DOC level	 **Most** Tbfree managed forest with healthy unbrowsed canopies **140%** increase in protection above DOC level
Large native invertebrates	 All large native invertebrate populations **severely affected** No increase in protection above DOC level	 **Most** possum-and rat-vulnerable large invertebrates well protected but a few still affected **120%** increase in protection above DOC level	 **Most** possum-and rat-vulnerable large invertebrates well protected but a few still affected **120%** increase in protection above DOC level
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Within-forest plants	 All within-forest plants **heavily defoliated** No increase in protection above DOC level	 **Some** but not all vulnerable within-forest plants protected **100%** increase in protection above DOC level	 **All** Tbfree managed forest with healthy unbrowsed within-forest plants **150%** increase in protection above DOC level
Annual tax contribution	$0	$25	$100

Selection				>>

8. In the previous Choice Tasks, were there any possum control outcomes that you ignored when making your choices? Select as many as applicable.

- ❑ Possum preferred canopy tree species
- ❑ Large native invertebrates
- ❑ Native birds
- ❑ Within-forest plants
- ❑ Annual tax cost
- ❑ I didn't ignore any of the information
- ❑ All

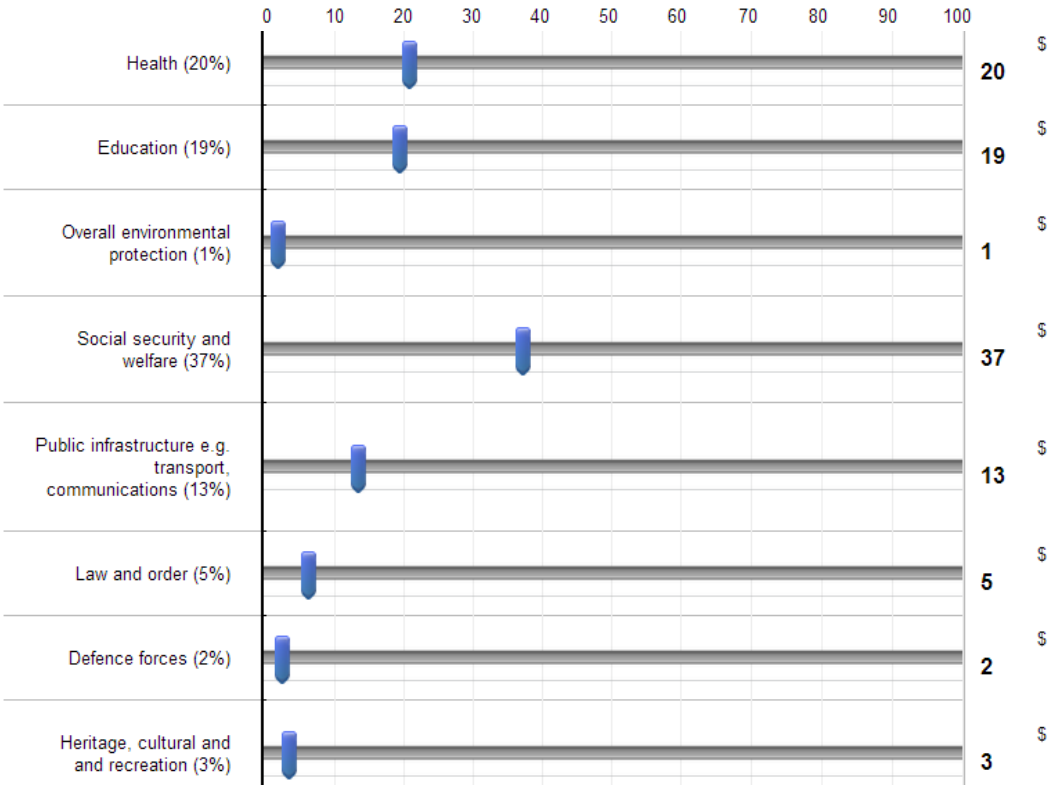
9. Sometimes the benefits of possum control do not continue once the control program has been stopped. What is the minimum length of time that benefits would need to last, for you to contribute to current control programs?

- ❍ At least 10 years
- ❍ At least 20 years
- ❍ For the foreseeable future
- ❍ The duration of benefits does not affect my willingness to contribute to possum control programs
- ❍ I don’t see any value in contributing to the benefits

10. Instead of spending money on protecting native forests, as in the previous choice tasks, would you rather have public funding spent on other areas?

Please indicate how you would spend $100 dollars of public funding across the following categories by dragging the slider across to a number between 0 and 100 for each category.

As an indication of the current level of public expenditure, the percentage spend from the 2013 Treasury Analysis of Government Expenses is included in brackets at the end of each line.



Demographics

To finish up we would like to ask a few questions about you. These questions allow us to check that we have a representative sample of people. Remember your responses are confidential and anonymous.

How many adults (18 and over) and children live in your household?

Adults _____
Children _____

What environmental organisations do you belong to?

- ❑ Forest & Bird
- ❑ Fish & Game
- ❑ Environment and Conservations Organisations of NZ
- ❑ Other(s) Please state _____
- ❑ None

Please select the highest level of formal education you have completed (or the equivalent outside of New Zealand).

- ❍ High school
- ❍ Trade/technical qualification or similar
- ❍ Undergraduate diploma/certificate/degree
- ❍ Postgraduate degree

Please select the option that best describes your current situation.

- ❍ Unemployed
- ❍ Retired
- ❍ Unpaid voluntary work
- ❍ Student
- ❍ Paid employment
- ❍ Home duties
- ❍ Self-employed
- ❍ None of the above

Thank you very much for your cooperation and contribution to this project. If you have any questions or comments please feel free to contact the authors

AERU

Agribusiness and Economics Research Unit

A Lincoln University Research Centre.
New Zealand's specialist land-based university.