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The Impact of Wilding Trees on Indigenous Biodiversity: A Choice Modelling Study

Geoffrey N. Kerr
Basil M.H. Sharp

Research Report No. 303
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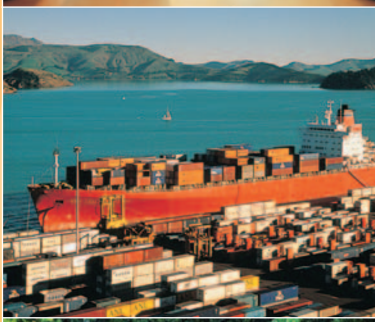

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Contents

List of Tables

List of Figures

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Executive Summary

Invasive species are typically non-indigenous species that adversely affect the habitat they invade. The adverse impact can be ecological (e.g. extinction of indigenous species), environmental (e.g. altering ecosystem function) and/or economic (e.g. reducing tourism). Wilding trees are invasive species that threaten large areas of the South Island high country. Once mature, most conifers are prolific producers of seed, whose spread, aided by wind, can cover large areas. Within a given location a wide range of values will attach to the services flowing from the South Island high country ecosystem. These values can be broadly described as use values and existence values. Examples of use value include recreation and grazing. Existence values may arise from knowing that the habitat for endangered indigenous species is being preserved. Estimates of these values provide information to decision makers charged with allocating scarce funds for biodiversity conservation.

This paper reports on the application of a choice experiment to estimate community preferences and values associated with the impact of wilding pines on indigenous species in the South Island. Defining the South Island high country as natural capital comprising *inter alia* an ecological system provides a conceptual link between the incursion of wilding trees and changes in the flow of services associated with the ecosystem. Economic valuation focuses on changes in utility associated with changes in the flow of services from the natural environment. In the case of wilding trees the aim is to measure the change in utility that attaches to changes in indigenous biodiversity.

The purpose of the choice experiment is to gain an understanding of the values that the community places on wilding trees *per se*, as well as on the effects of wilding trees on native species. The idea underlying choice modelling is relatively simple. Alternative attributes of the high country ecosystem are defined using information on the biology of wilding tree spread and their likely impact. These attributes are then combined into alternative states of the high country that are presented as options to individuals, who are then asked to indicate their single preferred choice. In 2007 two focus group meetings, one in Auckland and the other in Christchurch, identified salient attributes of wilding conifers in the high country and its ecosystem. Results from the two focus group meetings formed the basis for designing the choice sets for the actual experiment.

In general, focus group participants were cognisant of the landscape implications of wilding pine trees, but had little understanding of their potential ecological implications. There also was little interest in addressing geographically distant wilding pine invasions.

The Mackenzie Basin was a case study for application of the choice experiment, with surveys undertaken only in the South Island. The status of three endangered species - *Hebe cupressoides*, the robust grasshopper (*Brachaspis robustus*), and the bignose galaxias (*Galaxias macronasus*) - were used as attributes in a choice experiment to value the ecological effects of wilding pine invasion. The payment vehicle for the money attribute was “cost to your household each year for the next five years”.

This study adopted an innovative approach that involved groups of participants to undertake the choice experiment at one sitting. This approach could be applied quickly and, relative to personal interviews, offered significant cost savings while providing many of the same advantages. Four schools – Riccarton Primary (Christchurch), Fairlie Primary, Twizel Area and Bluestone Primary (Timaru) - hosted community meetings at which the choice experiment was applied. Members of the communities, who were recruited without any

knowledge of the topic of the investigation, were willing to engage in the choice experiment and were able to make a series of consistent choices that revealed their preferences about the outcomes of management of wilding pine trees in the Mackenzie Basin.

Simple statistical models were able to explain a large proportion of the variance in people's choices. Statistical power was enhanced significantly by the use of two different models that allowed for respondent heterogeneity. While interactions models that accounted for individual characteristics were significant improvements over the base multinomial logit model, they were not as good as the latent class models. The superior explanatory power of latent class models indicates the existence of at least two distinct groups of preferences within each community.

Focus group participants suggested that distant urban populations did not view wilding pines in the South Island high country as an issue of much relevance to them, raising the prospect of a significant distance-decay effect in values. However, in most cases differences in values within communities are far more significant than differences in values between communities.

The samples were not designed to be representative of each community, or for the selected communities to be representative of the whole of the South Island. However, it is possible to use the results to gain an understanding of the likely magnitude of values for protection of the three endangered species from extinction over the next 20 years. For example, assuming a ten per cent discount rate, the present value of maintaining the population of *Hebe cupressoides* at its present population, rather than becoming locally extinct, yields a present value of $138 per household. Aggregating this figure over approximately 300,000 households in the South Island yields a total present value benefit estimate in the order of $41 million. Despite the conservative assumptions utilised in their construction, these value estimates indicate that the community is willing to spend large amounts of money to protect these species. The value estimates derived here, combined with information on the costs of species preservation, whether by managing wilding pines or other methods, could form the foundations for cost-benefit analysis of species protection programmes.

Chapter 1
Introduction

The South Island high country ecosystem consists of a wide array of flora and fauna, some of which are indigenous, functioning together with non-living physical resources such as soil and water. Biodiversity is often used as a measure of the health of an ecosystem. Attempts at measuring biodiversity include indicators such as the number of species, population viability and distinctiveness. However, in the absence of a conceptual framework the notion of biodiversity offers little guidance for assessment of the value of biodiversity and the design of policy to address invasive species (Weitzman, 1998; Mainwaring, 2001).

Invasive species are typically non-indigenous species that adversely affect the habitat they invade. The adverse impact can be ecological (e.g. extinction of indigenous species), environmental (e.g. altering ecosystem function) and/or economic (e.g. reducing tourism). Wilding trees are invasive species that threaten large areas of the South Island high country. When faced with allocating scarce funds for biodiversity conservation, ecological indicators need to be complemented by information on economic value (Harding, 1994). Within a given community a wide range of values will attach to the services flowing from the South Island high country ecosystem. These values can be broadly described as use values and existence values. Examples of use value include recreation and grazing. Existence values may arise from knowing that the habitat for endangered indigenous species is being preserved.

Economic evaluation of strategies to manage invasive species relies on information on the benefits and costs arising from the management intervention. Benefits of invasive species management take many forms. Avoided market production losses are often readily evaluated using commercial information on reduced profitability. However, the market does not generate information on the loss of indigenous species arising because of unwanted aliens. Recreation and tourism often fall in the middle — some impacts might be of a commercial nature (e.g. loss of opportunities for guided tourism), other impacts will not be priced (e.g. reduced wilderness experience for backpackers). The total cost of intervention includes the direct costs of the intervention (which may or may not be easily estimated), the indirect commercial costs, plus non-market costs including environmental, health, social, recreational and other impacts arising from the management intervention.

The range of non-market effects can be large and non-market values may be much bigger than commercial effects. Consequently, accuracy in non-market valuation estimation can be important. There are now well-established methods for measuring non-market values of the types affected by invasive species.

In this paper we report on the application of a choice experiment to estimate community preferences and values associated with the impact of wilding pines on indigenous species in the South Island. The project has two specific objectives:

- Provide estimates of the money value of attribute changes caused by wilding pines and/or their management. These attributes include landscape, endangered flora and fauna, and ecosystem function, which may prove of use in the future to assess other invasive species cases which affect these environmental attributes.

- Contribute to a database of New Zealand values, enhancing prospects of valuation function transfer and meta-analysis (http://learn.lincoln.ac.nz/markval/). The data base is of potential benefit to Biosecurity New Zealand (BNZ) and regional units of government responsible for biosecurity management. Attribute values derived from this study may be useful in calibrating transfer of values from studies conducted in other countries, helping to overcome acknowledged biases associated with international value transfer (Navrüd and Ready, 2007).

The report is structured as follows. Chapter 2 begins with an overview of the management problem, a brief outline of the biology underpinning the spread of wilding trees and their impact on attributes of the high country environment. The experiment is described in Chapter 3, including the structure of the economic model and its interpretation. The approach of using focus groups to prepare photographic images of alternative attributes of the high country environment assuming different levels of wilding tree incursion and the econometric results are presented in Chapter 4. Chapter 5 provides a conclusion to the study.

Chapter 2
Study Background

Wilding trees threaten to invade large areas of the South Island. One recent estimate is that wilding conifers threaten over 210,000 hectares of the South Island administered by the Department of Conservation (DOC) (Harding, 2001). Wildings also threaten private land, pastoral leases and unoccupied Crown land. The ability of wilding pines to spread over large areas is illustrated by the case of an initial planting of 250ha which has spread to over 100,000ha of conservation and private land in the Mid Dome region of Southland (Department of Conservation, 2006).

2.1 Biology of spread

Ledgard and Langer (1999) and Ledgard (2003) describe the manner in which wilding pines spread. Most conifers can grow cones at between eight and thirteen years of age, producing cones every year, with heavy seed production every three to five years. In a good year, a 12-year old lodgepole pine is capable of producing 15,000 seeds. Most dispersal is by wind, usually to the south-east of the source because of the prevailing north-west winds. Autumn and winter are the main periods of seed dispersal. The vast majority of seed germinates within a year of dispersal but the occasional seedling can emerge after four to five years. Trees produce cones earlier and often in greater quantity in drier areas than in wetter areas, however germination is slower in drier sites.

The majority of spread occurs from the fringe areas with young trees emerging within a few hundred metres downwind of the parent trees. However, seed can travel long distances – over ten kilometres — when the parent trees are located on sites exposed to prevailing winds. Trees establishing some distance from the parent trees are referred to as outlier trees which, if not removed, eventually parent a new pocket of wildings. North and Ledgard (2005) use a mathematical model to depict the potential spread of wilding pines in Canterbury's Mackenzie Basin.

2.2 Effects of wilding trees

Defining the South Island high country as natural capital comprising *inter alia* an ecological system provides a conceptual link between the incursion of wilding trees and changes in the flow of services associated with the ecosystem. In the absence of development and incursions of invasive species this natural asset can provide a flow of services over a long period of time. Land development – such as subdivision for lifestyle blocks or conversion to intensive agriculture – can dramatically alter the flow of natural services. The impact of invasive species, while perhaps less obvious, can also impact the structure and functioning of the ecosystem. A characteristic of these impacts is the slow and non-obvious way they become manifest in indicators such as indigenous biodiversity. Harding (2001) provides a comprehensive description of wilding pine impacts. The incursion of wilding pines can change the flow of services from the natural asset in the following ways.

1. *Recreation:* wilding trees alter the quality of recreational experience by making access more difficult, obscuring indigenous flora and fauna, and changing the character of recreation sites.
2. *Plant communities:* wilding pines compete with low-stature plants — such as tussocks — for space, sunlight, and nutrients. Aggressive incursions can lead to localised extinction of plant communities. Changes in plant communities can affect habitat availability for fauna.
3. *Individual species:* the survival of individual plant and animal species is threatened by wilding trees. For example, *Hebe cupressoides*, indigenous to the high country, is threatened with local extinction by wilding conifers. Indigenous animal species, such as lizards, invertebrates and freshwater fish may be affected. However, wilding tree incursions can be advantageous for some species suited to the dense canopy and capable of establishing in place of species suited to the more open conditions of tussock grasslands.
4. *Soils and hydrology:* wilding conifers compete for water and nutrients with the net effect of reducing the supply of both to the natural ecosystem which, in turn, impacts the indigenous species that depend on a sustained flow of water and nutrients for their growth and survival. Reduced downstream water availability may have impacts on businesses and communities reliant on those water sources.
5. *Landscape values:* the extensive tussock grasslands landscape of the South Island high country changes with the incursion of conifers. The natural contour of the land can be obscured and the colour and texture of the landscape altered dramatically.
6. *Historic and cultural assets:* wilding tress can deny visitors visual and physical access to Māori pā sites, early mining sites and remnant buildings associated with early pastoral farming. They may also physically damage or destroy some sites.
7. *Land use:* wilding trees directly compete with pastoral agriculture. Indirectly, incursions can reduce water yields lowering the supply of water to pastoral systems of agriculture.

The effects of wilding tree incursion into the high country will obviously vary from site to site. For example, in some areas the predominant effect of wilding trees could be smothering of indigenous biota while in other areas impact may be primarily visual.

2.3 Economic problem

Simply stated, the economic problem is one of choosing the management strategy that yields maximum net benefits. From the above discussion of the effects of wilding trees it is clear that their spread has the potential to reduce the flow of benefits that individuals attach to the high country. These benefits might derive from the "natural" landscape, reduced opportunities for recreation, financial impacts on businesses, or simply the knowledge that indigenous habitat and its flora and fauna are being preserved. Once established, wilding trees reduce biodiversity, threaten plant communities and possibly lead to local extinctions — outcomes that the community might consider to be costs. The magnitude of the money value that the community attributes to this latter class of costs is unknown and is the focus of this study.

There are three readily identifiable options for management. First, managers could simply adopt a "*do-nothing*" approach. Self-sown forests can create a valuable resource but the majority do not. *Containment* is a second option. Where large areas of unwanted spread already exist, control zones can be used to surround containment areas, where wildings are tolerated. In areas where wilding spread is not wanted, managers check for wildings every 5-8 years, particularly outlier trees and those on take-off sites. Wilding trees could be *removed* by hand pulling (<50 cm tall) or by cutting at ground level with hand tools or machines such as chainsaws and scrub-cutters. The cost of removal ranges from a few dollars to many hundreds per hectare, depending on age, stocking and type of terrain (Natural Solutions for Nature 2004; Willemse *pers. comm.*). Clearly, different states of the South Island high country can be envisaged depending on the management strategy adopted. The attributes associated with these alternative states become the basis for framing the choices put to survey participants as described in Chapter 3.

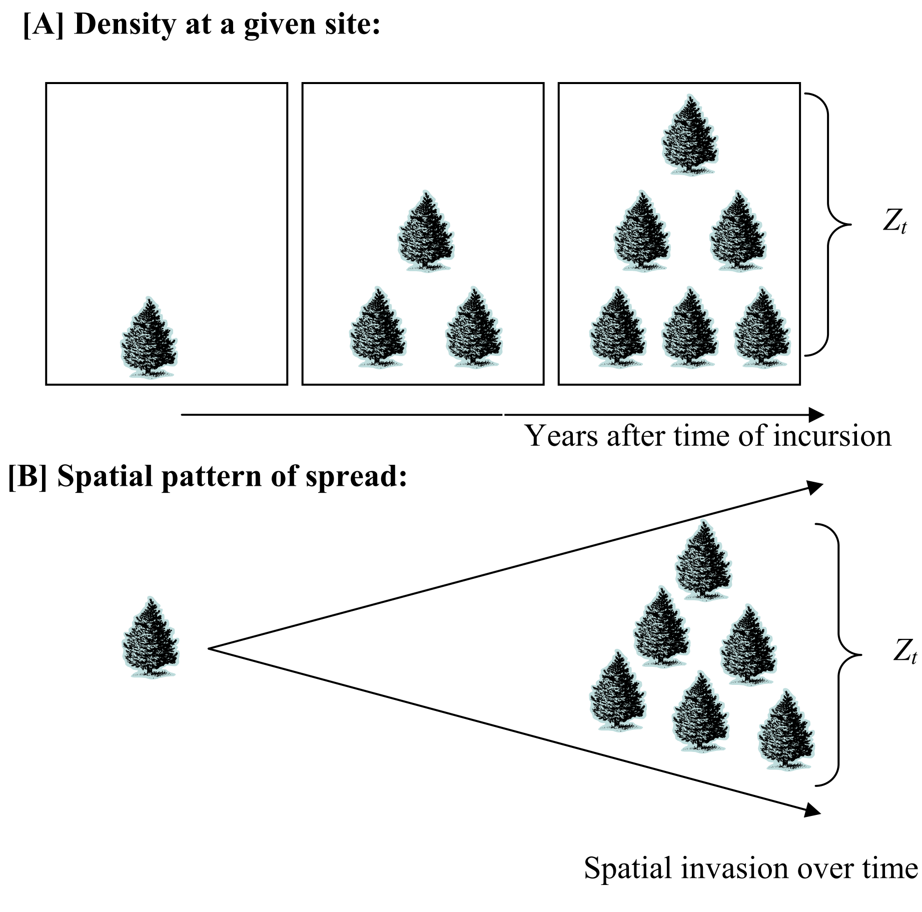
Chapter 3
Choice Modelling

Economic valuation focuses on changes in welfare (also termed utility) associated with changes in the natural environment. In the case of wilding trees the aim is to measure the change in utility that attaches to changes in indigenous biodiversity. As noted above the incursion of wilding trees can directly reduce biodiversity by smothering indigenous species and can indirectly impact biodiversity by altering the structure and functioning of the ecosystem. The purpose of the choice experiment is to gain an understanding of the values the community places on wilding trees *per se*, as well as on the effects on wilding trees on native species. This chapter provides a structure for the valuation problem, briefly describes choice modelling, and describes the specific approaches adopted in this study.

3.1 Problem structure

The state of the high country at a given time *t* is described by a set of amenity attributes (Z_t), such as the existence of indigenous flora and fauna and absence of exotic trees. The flow of amenity attributes is impacted by the presence of wilding trees at a particular point in time (W_t) and the controls applied to manage (M_t) their spread. Figure 3.1 illustrates the mapping relationship that underpins the structure described by $Z_t(W_t(M_t))$. For example, a single wilding pine can, within a short period of time, produce sufficient seed to enclose a given area. The upper diagram [A] in Figure 3.1 shows the density of trees as a function of time. If this site was tracked over time a description of the attributes (Z_t) might show biodiversity declining as density increased. In principle management can intervene at any point in time: the do-nothing option would, in all likelihood, see enclosure, whereas eradication could be applied at low cost initially or at higher cost later on. When to intervene is a matter of choice and the results of this research can assist decision makers in arriving at a decision. The lower diagram [B] in Figure 3.1 shows that spread will progress spatially as well. That is, from a single tree it is possible for wilding trees to fan out over a wide area. Once established they can progressively infill the intervening space. Many patterns are possible and Figure 3.1 should be interpreted in this light.

Figure 3.1: Two possible patterns of invasion



Assume that individual *j* can form preferences over the set of attributes (Z_t) and that these preferences can be represented by a utility function $u_j(Z_t)$. It is then possible to estimate the change in utility associated with a management action as follows:

$$\Delta M_t \rightarrow \Delta W_t \rightarrow \Delta Z_t \rightarrow \Delta u_j(Z_t)$$

The presence of *t* complicates matters immensely. The quantum of trees at any one time can be influenced by the amount of management activity at that time, and at all previous times. Similarly, the levels of attributes at any time (such as the populations of particular species) may be affected by the quantum of trees at any previous time. Consequently, utility at time *t* is dependent upon activities at all previous times.

3.2 Choice model

A choice experiment presents members of the target population with a limited number of options for future states of the world. Participants are asked to report their single most preferred alternative from this limited set. This process is repeated a number of times with different alternatives used each time. Each choice alternative is defined by the state of a common set of attributes, including a monetary attribute. Attributes describe the physical state of the world (extent of wilding invasion, species, location, etc.) or describe its consequences (impact on recreational access, water yield, local species extinctions, etc.), depending on what is to be valued. Attribute levels differ across alternatives based on a statistical experimental design that allows the analyst to mathematically infer values from the choices that participants make. Overviews of choice-based experimental approaches to valuation are provided by Bateman *et al.* (2002), Bennett and Blamey (2001), Champ *et al.* (2003), Hensher *et al.* (2005), Kanninen (2007), and Louviere *et al*. (2000).

Choice models typically employ a linear utility function of the form:

$$V_k = V(Z_k, Y_k) = \beta_0 + \beta_1 Z_{1,k} + \beta_2 Z_{2,k} + \ldots + \beta_n Z_{n,k} + \beta_Y Y_k = \boldsymbol{\beta Z'} + \beta_Y Y_k \qquad (1)$$

Where V is the observable component of utility, Z_k are choice attributes (or transformations of choice attributes) under some scenario (k). Y_k is the cost to the individual in scenario k. $\boldsymbol{\beta}$ is a vector of coefficients of marginal utilities for each attribute, and β_Y is the marginal utility of income. In order to clarify the nature of the changes involved in using a choice experiment, socio-economic effects have been suppressed. However, it is a straightforward matter to extend this utility function to permit characteristics of the individual to affect utility. Attributes differ between choices, but coefficients in the utility function (the betas) do not. Data analysis entails selection of the vector of coefficients that maximises the probability of obtaining the observed choices. This model allows evaluation of specific management options. Marginal rates of substitution between attributes are simply the ratios of the estimated coefficients.

An important advantage of the choice modelling approach for the evaluation of management options is that it avoids the need for monetisation. Many of the problems encountered in applying stated preference techniques arise because of the need to include monetary payments. For example issues arise because of payment vehicle biases, warm-glow effects, and anchoring biases or value cues implied by money attributes (see, for example, Mitchell and Carson, 1989). In the absence of monetisation there is no need to identify a suitable payment vehicle, or to worry about payment vehicle biases, lack of trust in agencies using money for the activities for which it was pledged, or anchoring biases. Inclusion of a cost attribute (Y) allows monetary measurement of the non-market costs of impacts caused by invasive pines. Knowledge of monetary values may not be important, particularly if monetary compensation is not relevant or is not permitted by government policy. For example, if a public agency has a fixed budget that must be spent on wilding pine management then monetization of the benefits of managing pines in different locations is not required. It is sufficient to know the relative benefits of management in each location (marginal rates of substitution) in order to allocate the wilding pine budget efficiently.

The utility function presented as equation (1) can be used to quantify management policy as follows. The change in utility (ΔU) associated with a change in non-money attributes is given by:

$$\Delta U = \sum_i \beta_i \Delta Z_i \qquad (2)$$

Attribute part worths (or implicit prices, d_i) are simply the attribute coefficients divided by the negative of the money coefficient $d_i = -\beta_i \beta_Y^{-1}$. Change in monetary value (ΔD) is then:

$$\Delta D = \sum_i d_i \Delta Z_i = -\Delta U \beta_Y^{-1} \qquad (3)$$

Equations (2) and (3) are used to provide non-monetary and monetary estimates of the benefits associated with the options for wilding trees management.

3.3 Design of choice sets

In 2007 two focus group meetings, one in Auckland and the other in Christchurch, were arranged by a professional market research agency. Ten individuals participated in each focus group. The focus groups were told the study was about the South Island high country, but not that the focus of the study was on wilding trees. After a brief introduction to the study a range of colour images depicting different patterns and densities of wilding tree invasion were put to the group members who then summarised their likes and dislikes in brief written notes alongside each photograph. The focus group facilitator did not provide any indication of what was "good or bad" about the photograph; individuals made their assessment based on their own preferences.

Figure 3.2, which shows a substantial wilding pine invasion at Craigieburn adjacent to State Highway 73, is an example of one of the photographs used in this process. As expected, people responded to a variety of different attributes in the photographs. For example, comments indicating what people liked about photograph 5 included: snow capped mountains, mountains and road, green and clean, colour of young trees, roads, trees, and openness. Dislikes expressed about the same scene included: road, no animals, infestation of exotics, barren, pine trees, erosion, and no snow. For the eight scenes depicted, the presence of wilding pine trees drew 41 positive responses and 15 negative responses.

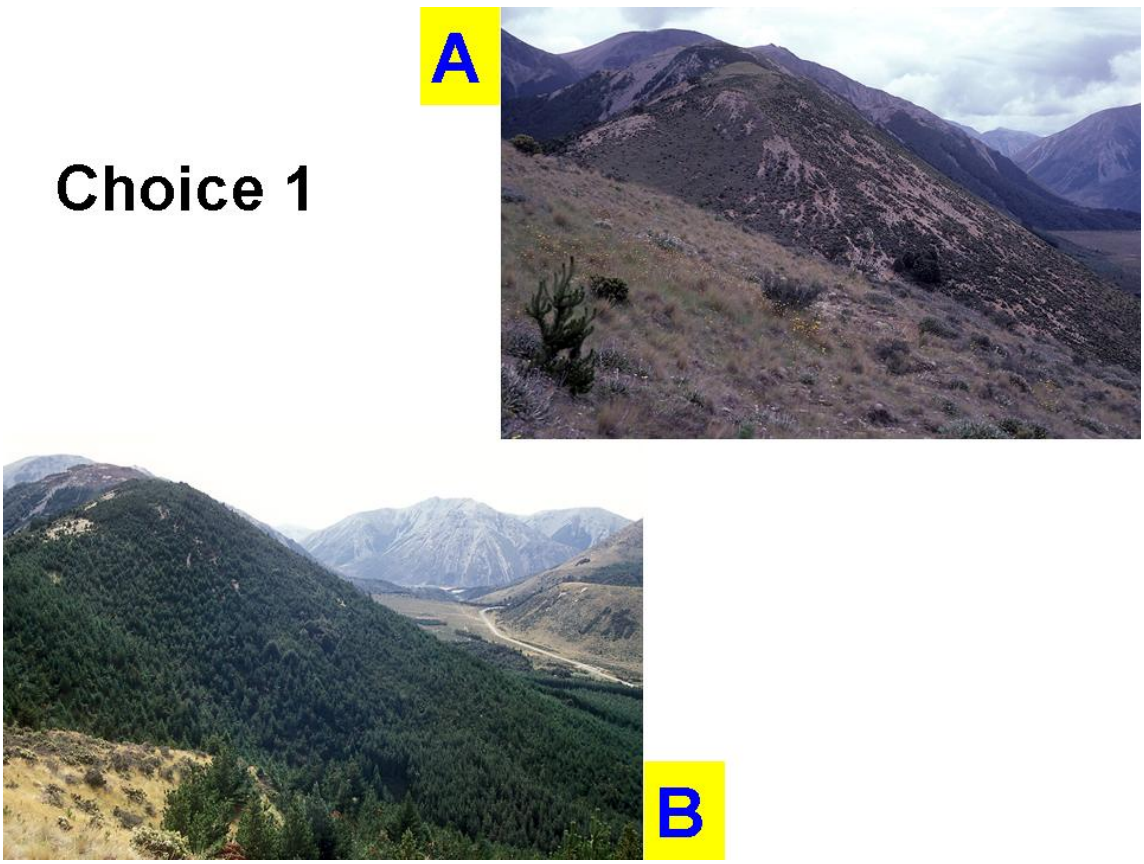
Figure 3.2: Example of a photographic prompt

Photograph 5

The second stage of the focus groups entailed seven binary choices in which participants were asked to choose Option A or Option B (Figure 3.3). Each option was a colour photograph of the same site pre- and post-wilding pine invasion. While great care was taken to match the photo points as closely as possible, in many instances the original photo points were inaccessible because of mature pine trees. The focus groups were not told the two photographs in each pair were the same site (although that was usually obvious), which photograph was taken first, or anything else about the scenes. Participants were asked to record why they chose a particular option.

The choices people made, and their supporting comments, indicated a strong preference for the post-wilding scenes. For Choice 1 (Figure 3.3) only two people preferred photograph A, one because it did not have a road and the other because it was “more natural”. The 18 people who preferred photograph B justified their preferences with terms including: greenery, more trees, representative of area, brighter, good use of land, it’s alive, trees, healthier, better scenery, more fertile, and symmetrical hill.

Figure 3.3: Example of a focus group binary choice



The 20 focus group participants preferred the post-wilding alternative on 102 occasions, compared with 35 for the pre-wilding alternatives (there were 3 incidences where people couldn’t choose). These findings, coupled with the earlier evaluations of single photographs revealed that focus group members had a strong affinity for pines in the landscape. Many of them did not like “barren” landscapes or lack of green vegetation.

To this point in the process care had been taken not to introduce any information about wilding pines. Consequently, the two photographic evaluation exercises were based entirely on participant perceptions. After results from the photo choices had been collected the focus groups were given a presentation informing them about wilding pines. The presentation defined wilding pines, described their distribution and how they spread and the potential extent of spread, identified effects of wilding pines, described management tools, and provided information on money costs of control. The following questions were then raised for discussion:

- What should be done about wilding pines?
  - Who should do it?
  - Where?
  - How?
  - What is it worth?

Responses to these questions indicated that most group members preferred the visual amenity provided by wilding pine trees and appreciated their ability to store carbon. There was some sympathy for the environmental impacts, but wilding trees were not seen as an issue for urban dwellers and participants showed little interest in contributing financial resources to control wilding pines.

The focus groups concluded with some simple choice experiment questions. Attributes included in the choices were:

> Control method, recreational access, number of endangered species threatened, pattern of spread, hectares of private land affected, hectares of public land affected, and cost to taxpayers.

Participants clearly understood the idea of a choice experiment and demonstrated an ability to carefully consider tradeoffs and make meaningful choices. They thought the attributes included were relevant and addressed all aspects that were salient to them.

Results from the two focus group meetings formed the basis for designing the choice sets for the actual experiment. In general, focus group participants were cognisant of the landscape implications of wilding pine trees, but had little understanding of their potential ecological implications. There also was little interest in addressing geographically distant wilding pine invasions. Consequently, it was decided to use the Mackenzie Basin as a case study, with surveys undertaken only in the South Island, but at various distances from the Mackenzie Basin to identify the importance of proximity. The Mackenzie Basin has been the focus of investigations into the extent (North & Ledgard, 2005; Stephens, 2003) and effects (Stephens, 2003) of wilding pines and hosts several species at risk from wilding invasions. The status of these species could be used as attributes in a choice experiment to evaluate the perceived value of ecological effects of wilding pine invasion.

The attributes *Wilding Pine Coverage* and *Predominant Pattern* were included to account for visual and recreational effects of wilding pines. Controlling for these effects was important so they did not confound estimates of values associated with effects on native flora and fauna. *Wilding Pine Coverage* and *Predominant Pattern* address the effects of wilding pines *per se*, but do not address biodiversity impacts. Three native species provided the focus for biological effects; *Hebe cupressoides*, the robust grasshopper (*Brachaspis robustus*) and the bignose galaxias (*Galaxias macronasus*).

Hebe cupressoides is a "greyish-green shrub forming a symmetrical rounded bush 1-2 m tall" (Norton, 2000). It is rated as *endangered* by de Lange *et al.* (1999) and *nationally endangered* by the Ministry for the Environment (2007). *Hebe cupressoides* is known historically from 39 different sites between Marlborough and Otago on the east coast of the South Island. It is now known at 19 localities, seven of which are in the Mackenzie Basin. About 75 per cent of the 1650 adult plants known are found at Saddle Creek in Otago. There are about 300 plants in the Mackenzie Basin (Norton, 2000). The New Zealand Plant Conservation Network (2007) notes the following threats.

> *Habitat loss has been a key factor in the historical decline of Leonohebe cupressoides, the dominant threats now are recruitment failure caused by invasive herbaceous plants that rapidly occupy the disturbed sites this species requires to germinate in.*

Invasions of wilding pines in the Mackenzie Basin have the potential to destroy the habitat of *Hebe cupressoides* by reducing germination via shading and competing with seedlings for water and nutrients (Norton, 2000).

The robust grasshopper (*Brachaspis robustus*) is classified as *nationally endangered* (Ministry for the Environment, 2007). It was rediscovered in the Ohau and Tekapo riverbeds in 1986 and is found only along a few sites on riverbeds, terraces and outwash materials in the Mackenzie Basin (Department of Conservation, 2007). *B. robustus* lives on land that has been disturbed 20-30 years ago, but their range is threatened. Hydro-electricity developments have forced them out of the braided river systems onto more open habitat which wilding pines are already encroaching upon (Chinn, pers. comm.).

Bignose galaxias (*Galaxias macronasus*) are found only in the Mackenzie Basin in small spring or wetland-fed tributaries (NIWA, 2007). They are chronically threatened and are classified as in *gradual decline* (Ministry for the Environment, 2007). The first Bignose galaxias was found in July 2001 (Elkington and Charteris, undated). Thirty-three sites are now known (Bowie, 2004), mostly characterised by "bottom gravels of shallow spring-fed creeks that flow into *Carex secta* wetlands … also found in areas of slow or no flow" (Elkington and Charteris, undated, p.10). All sites lie upstream of Lake Benmore and there are no sites above the glacial lakes in the Mackenzie Basin (Bowie, 2004). These habitats are threatened by wilding pine invasion.

The money attribute was "cost to your household each year for the next five years". The payment vehicle was household rates levied to fund management of wilding pine trees, as provided for under the Biosecurity Act (1993). Money values were chosen to cover a significant proportion of the range identified in pretests, they were $0, $25, $50, $100.

An example of a choice set is shown in Figure 3.4. Rows in the choice set represent a given attribute; such as wilding pine coverage, state of the robust grasshopper, and so on. Columns represent scenarios, which are described by a set of attribute levels including cost to the participant's household.

Figure 3.4: Example of a choice set

Outcomes In Twenty Years	Outcome Scenario A	Outcome Scenario B	Outcome Scenario C
Wilding Pine Coverage	5%	10%	2%
Predominant Pattern	Large areas	Scattered	Large areas
Hebe cupressoides	Locally Extinct	Same as now	Locally extinct
Robust grasshopper	Extinct	Same as now	Extinct
Bignose galaxias	Extinct	Same as now	Extinct
Cost to your household each year for the next 5 years	None	None	$100

3.4 Data collection

There are several methods available for data collection, including personal interviews, postal surveys, telephone surveys and internet-based surveys. Telephone surveys are unable to convey either the quantity or quality of information required to define the attributes of the choices. Cognitive demands of participants in telephone surveys would be immense, requiring memorisation of the levels of six attributes for each of three possible outcomes. An internet survey was not considered because of time and logistical implications. Personal interviews offer advantages because interviewers can insure that the target recipient is the person who completes the survey, response rates are higher, respondents cannot "skip ahead" and receive information out of the intended order, visual aids can be employed that are unavailable in postal and telephone surveys, and interviewers can evaluate understanding. However, personal interviews are expensive, particularly in rural communities distant from major centres. Postal surveys are relatively cheap methods of data collection, but cannot convey the depth of information or obtain the same quality data as personal interviews (Kerr & Sharp, 2003).

This study adopted a mixed strategy by organising groups of participants to undertake the choice experiment at one sitting. This approach offered significant cost savings relative to personal interviews while providing many of the advantages of personal interviews. In addition, the group approach could be applied much more quickly than an equivalent number of personal interviews.

Four schools – Riccarton Primary (Christchurch), Fairlie Primary, Twizel Area and Bluestone Primary (Timaru) – agreed to host meetings at which the choice experiment would be applied. In order to participate, each school was required to recruit between 30 and 60 community members. In addition to recruitment, the schools provided the venues and projection facilities and in return received a $50 per participant contribution to the school. Schools were instructed to obtain the most diverse audiences possible. They were encouraged not to rely on parents and teachers, but to recruit people from all sectors of the community including friends, relatives, neighbours, business colleagues, sports affiliates, etc.

Each group was given an introductory presentation that described what wilding pine trees are, their potential to spread to different environments, their impacts, and methods and costs of control. Topics addressed in the presentation are listed in Appendix A. The groups then completed the choice experiment exercise, which entailed each individual responding to 16 different choice events. The choices were developed using a fractional factorial design that ensured orthogonality (Appendix B). The four data collection meetings were completed in August 2007.

Chapter 4
Results

4.1 Participants

A total of 165 people completed the choice experiment. The characteristics of the participants are summarised in Table 4.1.

Table 4.1: Participants

	Twizel	Fairlie	Timaru	Christchurch
Number of people in the respondent's household (mean)	2.92 (1.46)	3.59 (1.66)	4.31 (0.96)	2.73 (1.32)
Number of children in the respondent's household (mean)	0.95 (1.37)	1.66 (1.54)	2.29 (0.96)	1.52 (1.26)
Respondent's age (mean, years)	52.5 (14.4)	45.1 (10.6)	38.2 (4.9)	43.2 (12.4)
Personal annual income group[a] (mean)	5.06 (1.70)	4.13 (2.10)	4.30 (2.26)	3.94 (1.86)
Male (proportion)	0.595	0.293	0.257	0.385
Maori (proportion)	0.027	0.049	0.029	0.058
NZ European (proportion)	0.919	0.707	0.971	0.750
University degree (proportion)	0.324	0.195	0.057	0.404
Live on farm (proportion)	0.135	0.317	0.057	Nil
Environmental group member (proportion)	0.108	0.024	0.029	0.115
N	37	41	35	52

(Standard deviations in parentheses)
[a] Upper bounds for income groups were:
1 $10,000; 2 $20,000; 3 $30,000; 4 $40,000; 5 $50,000; 6 $70,000; 7 $100,000; 8 unlimited.

There are some notable differences between groups. Fairlie's rural location is evidenced in the high proportion of farm dwellers in the sample. Twizel differed from the other locations in the high proportion of males participating, the high average age and the low number of children in the household. Fairlie and Timaru had low representation from environmental group members. Twizel and Christchurch had high proportions of participants with a university degree. Ethnicity was largely New Zealand European, with the most diversity in Fairlie. Timaru had a low proportion of males, the highest number of household members, the most children, the highest proportion of New Zealand Europeans, the lowest proportion of university degrees, and was the youngest group.

4.2 Data analysis

Analysis of choice experiment results entails fitting mathematical models to explain the choices made. The underlying rationale is that people will select the choice that they expect will be of most benefit to them. The individual's estimate of the utility to them of each outcome is a function of the levels of each of the attributes and some randomness.

The analyst specifies a mathematical function that describes total benefit (utility) from any combination of attributes. Estimated utility is dependent upon the form of the function fitted, the level of the attributes, and the estimated model coefficients. The form of uncertainty assumed about the choices people make determines the nature of the mathematical model fitted. The most common function utilised in this type of analysis is the Multinomial Logit Model (MNL), utilising a linear utility function. The MNL model assumes identically distributed Gumbel error terms for each of the choice alternatives. This model was used for initial investigation of responses from each community. Initial analysis utilised a basic model that did not account for respondent characteristics (Table 4.2). The four locations were analysed separately to account for potential scale differences in error terms.

Table 4.2: Basic model

	Twizel	Fairlie	Timaru	Christchurch
Constant	-.3614	-.5143**	-1.462***	-.7226***
Cover	-.09587***	-.1057***	-.08458***	-.08504***
Large blocks	-.3499**	-.7024***	-.8462***	-.6971***
Hebe cupressoides	.5198***	.5274***	.8049***	.7247***
Robust grasshopper	.9187***	.9013***	1.359***	1.032***
Bignose galaxias	1.018***	.8666***	2.114***	1.0198***
Money	-.007373***	-.01617***	-.01451***	-.007664***
LL_{UR}	-434.631	-462.148	-218.825	-518.715
LL_R	-540.910	-602.511	-409.088	-684.358
Rho^2	.196	.233	.465	.242
N	589	651	559	832

* $\alpha<0.1$ ** $\alpha<0.05$ *** $\alpha<0.01$

The variables in the basic model are:

Constant	No change from the base case
Cover	% of the Mackenzie Basin covered in wilding pines
Large blocks	1 if Wilding pines are predominantly in large blocks, else 0
Hebe cupressoides	1 if *Hebe cupressoides* is in present state, 0 if *Hebe cupressoides* is locally extinct
Robust grasshopper	1 if the Robust grasshopper is in present state, 0 if the Robust grasshopper is extinct
Bignose galaxias	1 if Bignose galaxias is in present state, 0 if Bignose galaxias is extinct
Money	Annual cost to the household for 5 years ($)

LL_{UR} is the log-likelihood score for the fitted model, while LL_R is log-likelihood for a model that incorporates constant terms, but does not include attributes. Quality of model fit is indicated by McFadden's Rho^2. A bigger Rho^2 indicates better fit. However, Rho^2 cannot be interpreted as the percentage of variance explained. The Rho^2 scores reported here approximate R^2 in linear regression of about 0.47 ($Rho^2 = 0.2$) to 0.85 ($Rho^2 = 0.46$), based on the equivalences reported in Hensher *at al.* (2005). These models are exceptionally good fits for this type of data.

This is a remarkably uniform set of results. In each case, every attribute is highly significant. The signs on attributes are the same, irrespective of location. Preferences are for less wilding pine coverage. For any given amount of coverage, people prefer that it is not in large, contiguous blocks. Continued existence of the three endangered species is valued positively, and respondents prefer lower personal costs.

The simple MNL model assumes that everyone within a community has similar preferences. One method to account for differences between individuals is to fit a model to each individual's choices. However, the individual model approach requires a very large number of choices by each individual and comes at high computational cost.

One approach to accounting for respondent heterogeneity is to use models that interact respondent characteristics and attributes to identify differences in value that can be explained by personal characteristics (Table 4.3).

The new variables introduced in the interactions models are:

MALE	1 if respondent is male, else 0
MODINCOME	1 if respondent has income greater than $30,000 p.a., else 0
FARM	1 if respondent lives on a farm, else 0
DEGREE	1 if respondent has a university degree, else 0
OLD	1 if respondent is 61 years or older, else 0
Scattered	1 if wilding pines are predominantly scattered, else 0

The three endangered species names are abbreviated. There were no farm residents in the Christchurch sample and only 2 in Timaru. There were no old people (over 61 years) in the Timaru sample. The numbers of observations in the interaction models are smaller than for the MNL models because of missing data for the interaction effects.

Quality of model fit cannot be compared directly for MNL and interaction models using Rho^2 because of the differences in numbers of parameters. A likelihood ratio test (Greene, 2000) is used to account for that factor. At each location the interactions model is preferred to the basic model on the basis of likelihood ratio tests using the same samples.

Twizel	LL_R (N=541) = -395.880	$\chi^2 = 75.824$	10 dof	P = .000000
Fairlie	LL_R (N=635) = -462.655	$\chi^2 = 47.008$	6 dof	P = .000000
Timaru	LL_R (N=480) = -197.529	$\chi^2 = 17.216$	1 dof	P = .000033
ChCh	LL_R (N=832) = -518.715	$\chi^2 = 4.148$	1 dof	P = .0417

The interaction models offer significant improvements over the simple MNL models in all cases.

In some cases no parameters are reported for the base attributes. For example, there is no parameter for Cover at Fairlie, although there is a parameter for Male*Cover. The negative sign on the interaction indicates that males viewed extra wilding pine coverage negatively, whereas the non-significance of the base attribute indicates a non-significant effect of cover for females.

Table 4.3: Interaction models

	Twizel	Fairlie	Timaru	Christ-church
Constant	-.4326	-.4899**	-1.309**	-.6549***
Cover	-.1185***	-.1140***		-.08497***
Large blocks	-.9607***		-.8337***	-.8778***
Hebe cupressoides	.8207***	.4735***	.9049***	.7253***
Robust grasshopper	1.312***	1.350***	1.419***	1.034***
Bignose galaxias	1.228***	1.158***	2.525***	1.022***
Money	-.008325***	-.01625***	-.01687***	-.007633***
MALE*Cover			-.1969***	
MALE*Large		-.4811*		
MALE*Hebe	-.4990**			
MALE*Grasshopper		-.5386**		
MODINCOME*Large	1.605***	-.5385***		
MODINCOME *Scattered	.8118**			
MODINCOME *Grasshopper		-.4454**		
MODINCOME *Galaxias		-.4211**	-.5417**	
FARM*Large		-.7265***		na
FARM*Hebe	-.5595*			na
FARM*Grasshopper	-.9167***			na
FARM*Galaxias	-.7594**			na
DEGREE*Large	-2.446**			
DEGREE *Scattered	-1.957*			.2285**
DEGREE *Hebe	.5643**			
OLD*Hebe		.7132**	na	
OLD*Grasshopper	-.4202*		na	
LL_{UR}	-357.968	-439.151	-188.921	-516.641
LL_R	-499.188	-588.341	-354.078	-684.359
Rho^2	.283	.254	.466	.245
AIC	1.386	1.424	0.821	1.261
N	541	635	480	832

* α<0.1 ** α<0.05 *** α<0.01

Wilding Pine Cover

The only effect detected for this attribute was in Timaru, where males preferred less cover. Cover was not significant for females.

Pattern of Cover

In Fairlie the aversion to large blocks of trees observed in the basic MNL model is driven by three personal characteristics. Farmers, Males and Older residents were all more likely than others to dislike large blocks of wilding pines. Different effects were observed in Twizel, where Higher income people (MODINCOME) showed no aversion to large blocks of wilding pines, but university graduates showed strong dislike for large blocks of wilding pines.

Hebe cupressoides

Twizel males were less concerned than Twizel females about loss of the hebe, as were Twizel farmers. Twizel university graduates showed more concern about loss of the hebe than did non-graduates. Older Fairlie residents were more concerned about loss of the hebe than their younger neighbours.

Robust grasshopper

In Fairlie, males and richer people were less concerned about loss of the robust grasshopper. Twizel farmers and older residents were less worried about the potential demise of the grasshopper than were others.

Bignose galaxias

Richer residents in Fairlie and Timaru and farmers in Twizel placed a lower value on loss of the galaxias than did other respondents in the same locations.

There is no consistent pattern of effects from personal characteristics across locations.

A pragmatic approach to modelling potential respondent heterogeneity has been adopted here using Latent Class Models (LCM: Swait 1994). "Latent Classes correspond to underlying market segments, each of which is characterised by unique tastes" (Louviere *et al.* 2000). The LCM is an extension of the MNL model that assumes that respondents can be a member of one of a predetermined number of classes. There are now two mathematical estimation problems: allocating people to classes and modelling preferences within each class. LCMs use a type of MNL model to allocate individuals probabilistically to classes. Consequently, the LCM can be likened to solving several MNL models simultaneously.

While extensive testing was undertaken to find socio-economic variables that helped to explain class membership, no significant determinants were found. Consequently, only simple models are reported here (Table 4.4). Latent class models significantly improve Rho^2 scores compared to MNL and interaction models. Tables 4.5 – 4.8 compare the fit of three different models for each location.

Table 4.4: Latent class models

	Twizel	Fairlie	Timaru	Christchurch
Class 1				
Constant	-2.628***	-1.806***	-1.812*	-2.039***
Cover	-.1089***	-.1112***	-.06037	-.09556***
Large blocks	-.6838***	-.7265***	-.8133***	-.7787***
Hebe cupressoides	.6446***	.5821***	1.268***	.8737***
Robust grasshopper	1.088***	.9647***	1.259***	1.257***
Bignose galaxias	1.296***	.9034***	2.608***	1.2291***
Money	-.004736***	-.1046***	-.008605***	-.008827***
Class 2				
Constant	-1.021***	.3433	-1.064**	.3380
Cover	-.1584***	-.1900**	-.1989***	-.08310
Large blocks	1.041***	-.7255	-.8362***	-1.041**
Hebe cupressoides	.4833*	-.01809	.2682	.06746
Robust grasshopper	.7915***	.8114**	2.660***	-.8319**
Bignose galaxias	.2735	1.363***	2.127***	-.6365**
Money	-.03218***	-.08104***	-.03523***	-.006804**
Prob (Class 1)	.7568***	.8544***	.6287***	.9222
Prob (Class 2)	.2432***	.1456***	.3713***	.0778**
$LL_{2\text{-class}}$	-355.874	-389.155	-200.683	-442.900
$LL_{1\text{-class}}$	-434.631	-462.148	-218.825	-518.715
$LL_{Constants}$	-540.910	-602.511	-614.124	-684.358
Rho^2	.342	.354	.673	.353
N	589	651	559	832

* $\alpha<0.1$ ** $\alpha<0.05$ *** $\alpha<0.01$

In each instance, Class 1 preferences mimic those of the basic model; preferences are for fewer trees in small blocks, lower personal costs and preservation of the endangered species. The one exception is the non-significance of the amount of wilding tree cover for Timaru. Class 2 (which is much smaller) shows some variants from that pattern. For example, large blocks of wilding pines are preferred by Twizel Class 2 respondents. The value of preserving *Hebe cupressoides* is positive, but of low significance for Twizel, but is not significant at other locations. In general, Class 1 members place higher values on environmental attributes than do members of Class 2.

Table 4.5: Twizel models

	Basic	LCM	Interactions
Class 1			
Constant	-.3614	-2.628***	-.4326
Cover	-.09587***	-.1089***	-.1185***
Large Blocks	-.3499**	-.6838***	-.9607***
Hebe cupressoides	.5198***	.6446***	.8207***
Robust grasshopper	.9187***	1.088***	1.312***
Bignose galaxias	1.018***	1.296***	1.228***
Money	-.007373***	-.004736***	-.008325***
Class 2			
Constant		-1.021***	
Cover		-.1584***	
Large Blocks		1.041***	
Hebe cupressoides		.4833*	
Robust grasshopper		.7915***	
Bignose galaxias		.2735	
Money		-.03218***	
Prob1		.7568***	
Prob2		.2432***	
MALE*Hebe			-.4990**
MODINCOME *Large			1.605***
MODINCOME *Scattered			.8118**
FARM*Hebe			-.5595*
FARM* grasshopper			-.9167***
FARM*galaxias			-.7594**
DEGREE*Large			-2.446**
DEGREE *SCAT			-1.957*
DEGREE *Hebe			.5643**
OLD*grasshopper			-.4202*
LL_{UR}	-434.631	-355.874	-357.968
LL_R	-540.910	-540.910	-499.188
Rho^2	.196	.342	.283
AIC	1.450	1.259	1.386
BIC	1.552	1.371	1.521
N	589	589	541

* α<0.1 ** α<0.05 *** α<0.01

Table 4.6: Christchurch models

	Basic	LCM	Interactions
Class 1			
Constant	-.7226***	-2.039***	-.6549***
Cover	-.08504***	-.09556***	-.08497***
Large Blocks	-.6971***	-.7787***	-.8778***
Hebe cupressoides	.7247***	.8737***	.7253***
Robust grasshopper	1.032***	1.257***	1.034***
Bignose galaxias	1.0198***	1.2291***	1.022***
Money	-.007664***	-.008827***	-.007633***
Class 2			
Constant		.3380	
Cover		-.08310	
Large Blocks		-1.041**	
Hebe cupressoides		.06746	
Robust grasshopper		-.8319**	
Bignose galaxias		-.6365**	
Money		-.006804**	
Prob1		.9222	
Prob2		.0778**	
DEGREE*Scattered			.2285**
LL_{UR}	-518.715	-442.900	-516.641
LL_R	-684.358	-684.358	-684.359
Rho^2	.242	.353	.245
AIC	1.264	1.101	1.261
BIC	1.303	1.185	1.307
N	832	832	832

* α<0.1 ** α<0.05 *** α<0.01

Table 4.7: Timaru models

	Basic	LCM	Interactions
Class 1			
Constant	-1.462***	-1.812*	-1.309**
Cover	-.08458***	-.06037	
Large Blocks	-.8462***	-.8133***	-.8337***
Hebe cupressoides	.8049***	1.268***	.9049***
Robust grasshopper	1.359***	1.259***	1.419***
Bignose galaxias	2.114***	2.608***	2.525***
Money	-.01451***	-.008605***	-.01687***
Class 2			
Constant		-1.064**	
Cover		-.1989***	
Large Blocks		-.8362***	
Hebe cupressoides		.2682	
Robust grasshopper		2.660***	
Bignose galaxias		2.127***	
Money		-.03523***	
Prob1		.6287***	
Prob2		.3713***	
MALE*cover			-.1969***
MODINCOME *galaxias			-.5417**
LL_{UR}	-218.825	-200.683	-188.921
LL_{R}	-409.088	-409.088	-354.078
Rho^2	.465	.509	.466
AIC	0.808	0.772	0.821
BIC	0.862	0.888	0.890
N	559	559	480

* α<0.1 ** α<0.05 *** α<0.01

Table 4.8: Fairlie models

	Basic	LCM	Interactions
Class 1			
Constant	-.5143**	-1.806***	-.4899**
Cover	-.1057***	-.1112***	-.1140***
Large Blocks	-.7024***	-.7265***	
Hebe cupressoides	.5274***	.5821***	.4735***
Robust grasshopper	.9013***	.9647***	1.350***
Bignose galaxias	.8666***	.9034***	1.158***
Money	-.01617***	-.1046***	-.01625***
Class 2			
Constant		.3433	
Cover		-.1900**	
Large Blocks		-.7255	
Hebe cupressoides		-.01809	
Robust grasshopper		.8114**	
Bignose galaxias		1.363***	
Money		-.08104***	
Prob1		.8544***	
Prob2		.1456***	
MALE*Large			-.4811*
MALE* grasshopper			-.5386**
MODINCOME *Large			-.5385***
MODINCOME *grasshopper			-.4454**
MODINCOME *galaxias			-.4211**
FARM*Large			-.7265***
OLD*Hebe			.7132**
LL_{UR}	-462.148	-389.155	-439.151
LL_R	-602.511	-602.511	-588.341
Rho^2	.233	.354	.254
AIC	1.441	1.242	1.424
BIC	1.489	1.345	1.515
N	651	651	635

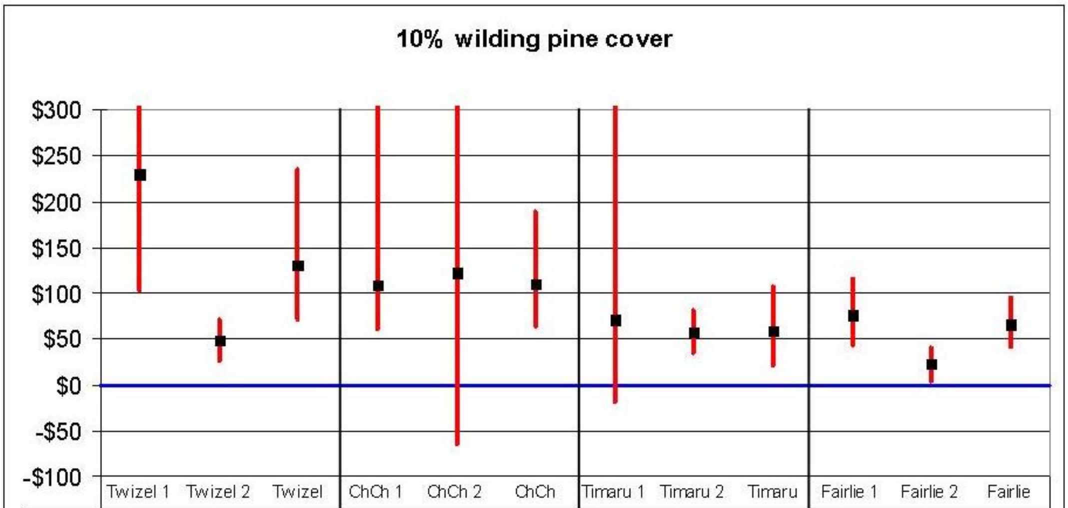
* $\alpha<0.1$ ** $\alpha<0.05$ *** $\alpha<0.01$

For each location the LCM model is best on the basis of AIC (Akaike Information Criterion) score. BIC (Bayesian Information Criterion) also prefers the LCM, except for Timaru where the basic model is preferred on the BIC. Overall, the LCM model performs best.

4.3 Attribute values

The money values estimated for each attribute are summarised in Figures 4.1 – 4.5. They are derived from the models in Tables 4.5 – 4.8 by dividing the relevant coefficient by the negative of the money coefficient. The bars show 95% confidence intervals (labelled Upper and Lower in the data tables) and the points show expected values. For each attribute and location there are three entries. Location1 and Location2 refer to the two latent classes, whereas Location refers to the basic model.

Figure 4.1: Money costs of 10 per cent additional wilding pine cover

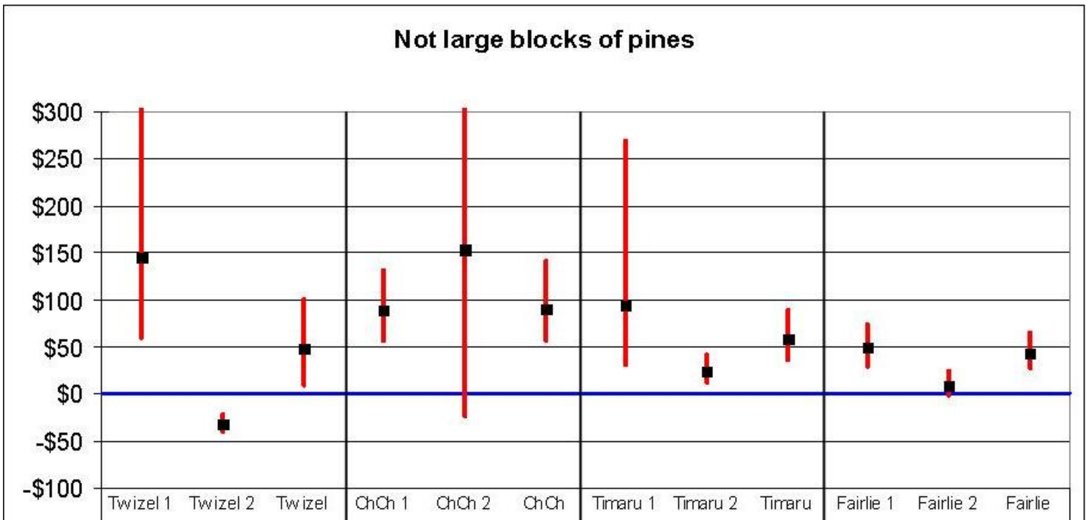


	Twizel 1	Twizel 2	Twizel	ChCh 1	ChCh 2	ChCh	Timaru 1	Timaru 2	Timaru	Fairlie 1	Fairlie 2	Fairlie
Upper	$788	$70	$236	$1,773	$436	$188	$429	$82	$107	$115	$40	$95
Lower	$104	$26	$71	$60	-$63	$65	-$18	$34	$21	$44	$5	$41
Expected	$230	$49	$130	$108	$122	$111	$70	$56	$58	$76	$23	$65

Wilding Pine Cover

Figure 4.1 shows that a ten percent increase in wilding pine coverage is viewed as a cost in all cases. Mean money values are similar for all four locations, and only two groups have 95% confidence intervals that are not significantly different from zero. There are significant differences between groups for Twizel and Fairlie, but not for Christchurch or Timaru.

Figure 4.2: Money benefits of avoiding large blocks of wilding pines

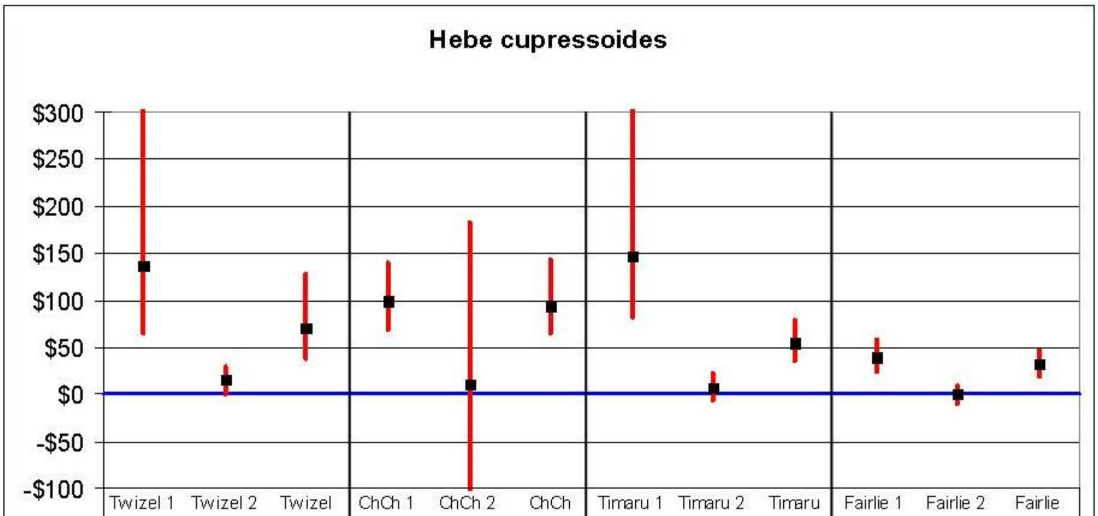


	Twizel 1	Twizel 2	Twizel	ChCh 1	ChCh 2	ChCh	Timaru 1	Timaru 2	Timaru	Fairlie 1	Fairlie 2	Fairlie
Upper	$494	-$22	$102	$132	$827	$142	$269	$41	$89	$74	$24	$65
Lower	$59	-$41	$10	$57	-$23	$56	$32	$12	$36	$29	-$2	$28
Expected	$144	-$32	$47	$88	$153	$90	$95	$24	$58	$50	$9	$43

Pine Distribution

Nearly every group preferred to avoid large blocks of pine trees. Apart from Fairlie, each location had one group with a large confidence interval around the value of avoiding large contiguous blocks of wilding pine trees. Despite that, there were differences in money values between groups at Twizel, Timaru and Fairlie. One group at Twizel preferred large blocks of wilding pine trees. There are no significant differences between locations for mean money values estimated using the basic model.

Figure 4.3: Money benefits of avoiding local extinction of *hebe cupressoides*

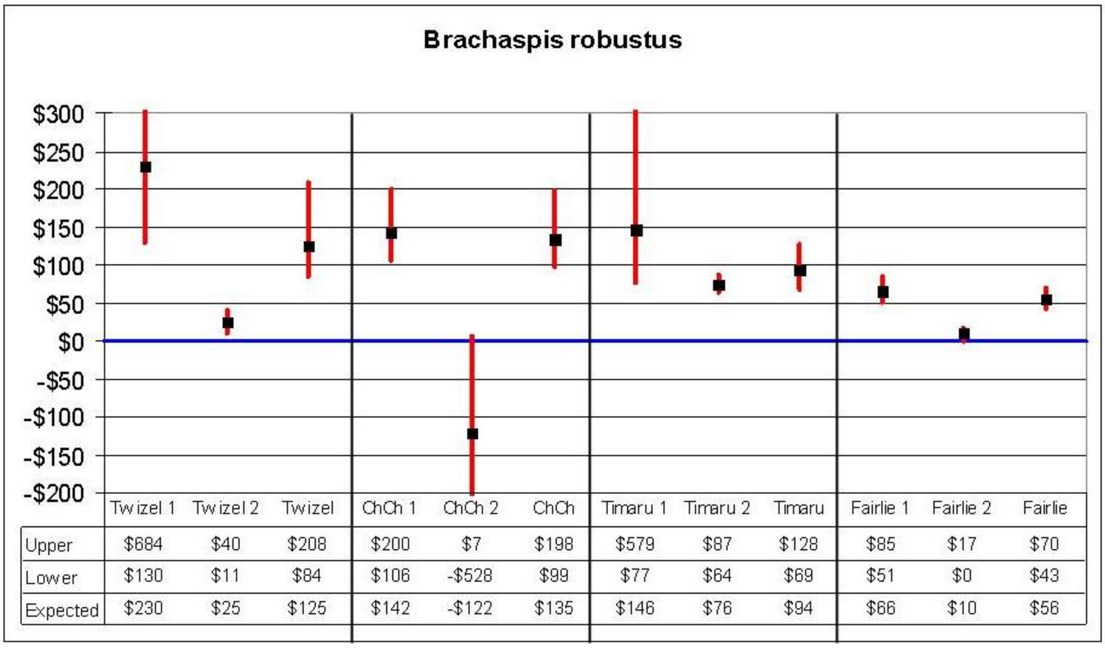


	Twizel 1	Twizel 2	Twizel	ChCh 1	ChCh 2	ChCh	Timaru 1	Timaru 2	Timaru	Fairlie 1	Fairlie 2	Fairlie
Upper	$443	$30	$127	$140	$183	$143	$475	$23	$79	$58	$9	$46
Lower	$66	-$0	$38	$69	-$163	$66	$82	-$6	$36	$24	-$10	$19
Expected	$136	$15	$71	$99	$10	$95	$147	$8	$55	$40	-$0	$33

Hebe cupressoides

At each location the money value for one group was not significantly different from zero. Using the basic model, Fairlie mean money value is significantly less than Christchurch.

Figure 4.4: Money benefits of avoiding extinction of *brachaspis robustus*

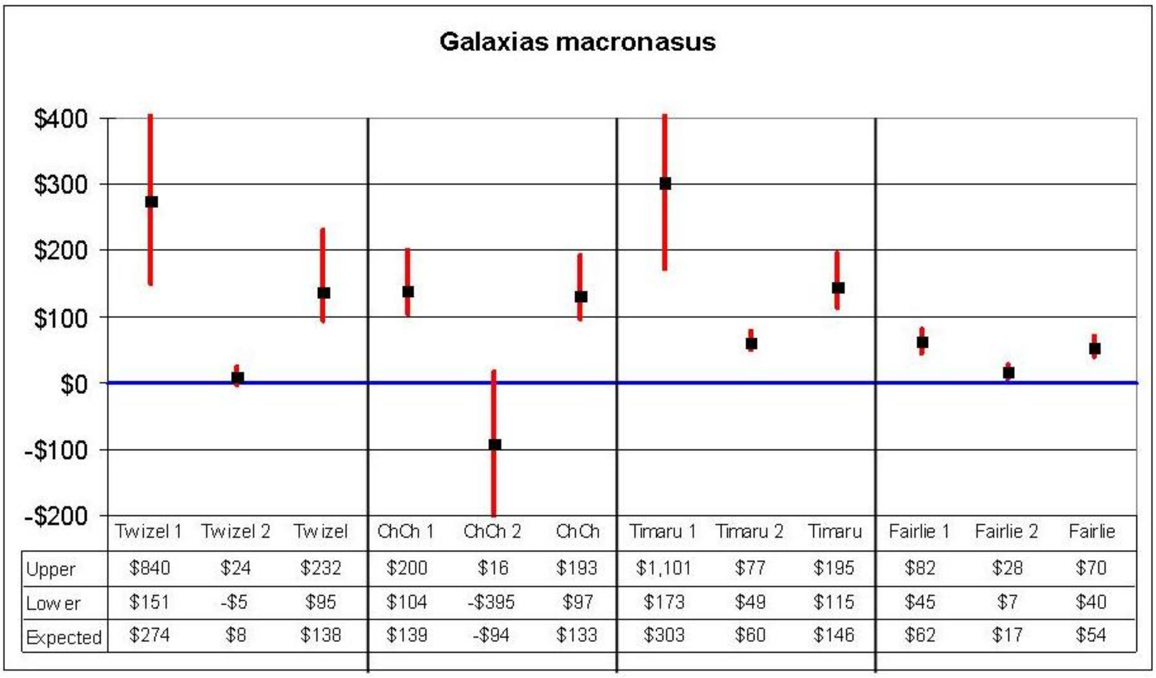


	Twizel 1	Twizel 2	Twizel	ChCh 1	ChCh 2	ChCh	Timaru 1	Timaru 2	Timaru	Fairlie 1	Fairlie 2	Fairlie
Upper	$684	$40	$208	$200	$7	$198	$579	$87	$128	$85	$17	$70
Lower	$130	$11	$84	$106	-$528	$99	$77	$64	$69	$51	$0	$43
Expected	$230	$25	$125	$142	-$122	$135	$146	$76	$94	$66	$10	$56

Brachaspis robustus

There are significant differences between classes within communities, with the most uniform values occurring at Timaru. Fairlie mean money value is significantly less than at the other locations.

Figure 4.5: Money benefits of avoiding extinction of *galaxias macronasus*



	Twizel 1	Twizel 2	Twizel	ChCh 1	ChCh 2	ChCh	Timaru 1	Timaru 2	Timaru	Fairlie 1	Fairlie 2	Fairlie
Upper	$840	$24	$232	$200	$16	$193	$1,101	$77	$195	$82	$28	$70
Lower	$151	-$5	$95	$104	-$395	$97	$173	$49	$115	$45	$7	$40
Expected	$274	$8	$138	$139	-$94	$133	$303	$60	$146	$62	$17	$54

Galaxias macronasus

The pattern of values is very similar to the values for *Brachaspis robustus*. Again Fairlie aggregate values are lower than for other communities.

4.4 Community values

The latent class models permit development of "profiles" of results for each class. These are presented for each location in Figures 4.6 – 4.9.

In each case where there are significant differences. Class 1 places higher values on the environmental attributes than does Class 2. For example, in the Twizel and Fairlie samples money values were lower for Class 2 for every attribute. A similar result occurred at Timaru, except that the value of Cover was not different between the two classes. The Christchurch sample yielded only two significant differences in money values between classes – for the robust grasshopper and the bignose galaxias. These results suggest the existence of two distinct groups in each of these communities, with one group placing very little value on preservation of environmental quality. However, the group with low environmental values was the smallest in each case (34 per cent, 15 per cent, 37 per cent & eight per cent for Twizel, Fairlie, Timaru and Christchurch respectively).

Figure 4.6: Twizel value profiles

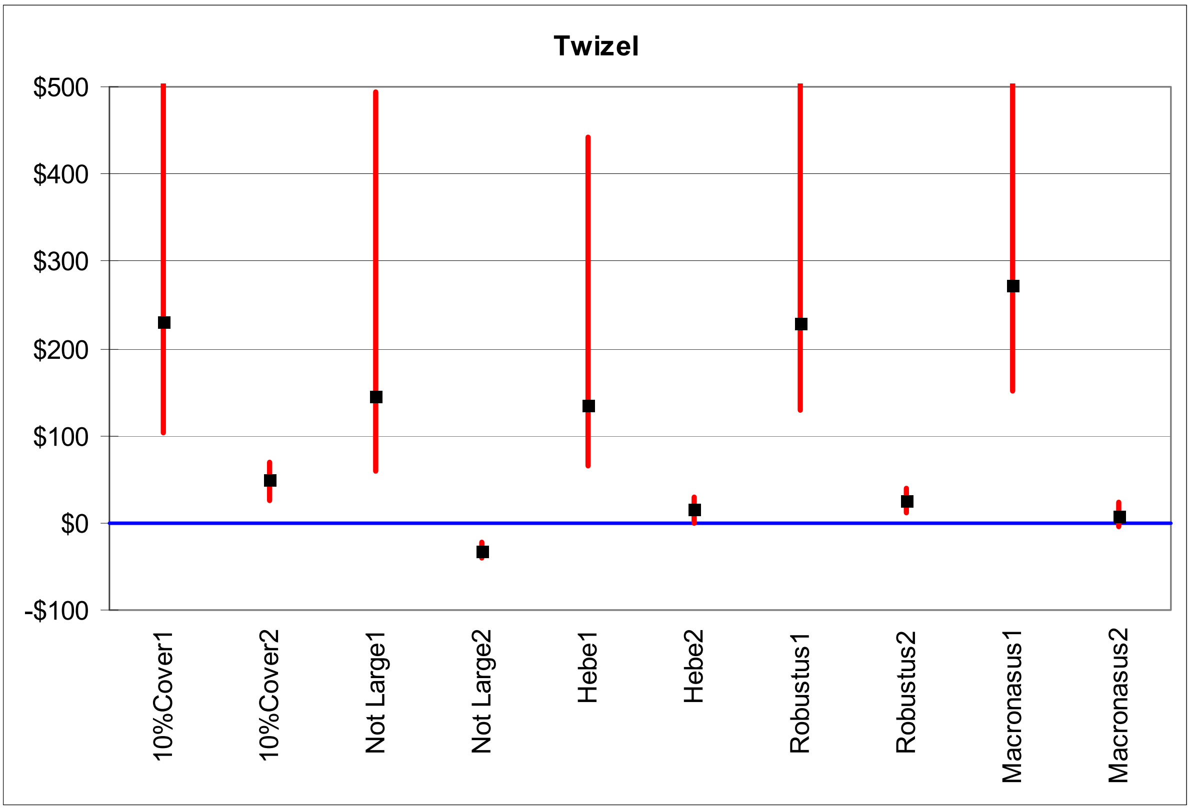


Figure 4.7: Christchurch value profiles

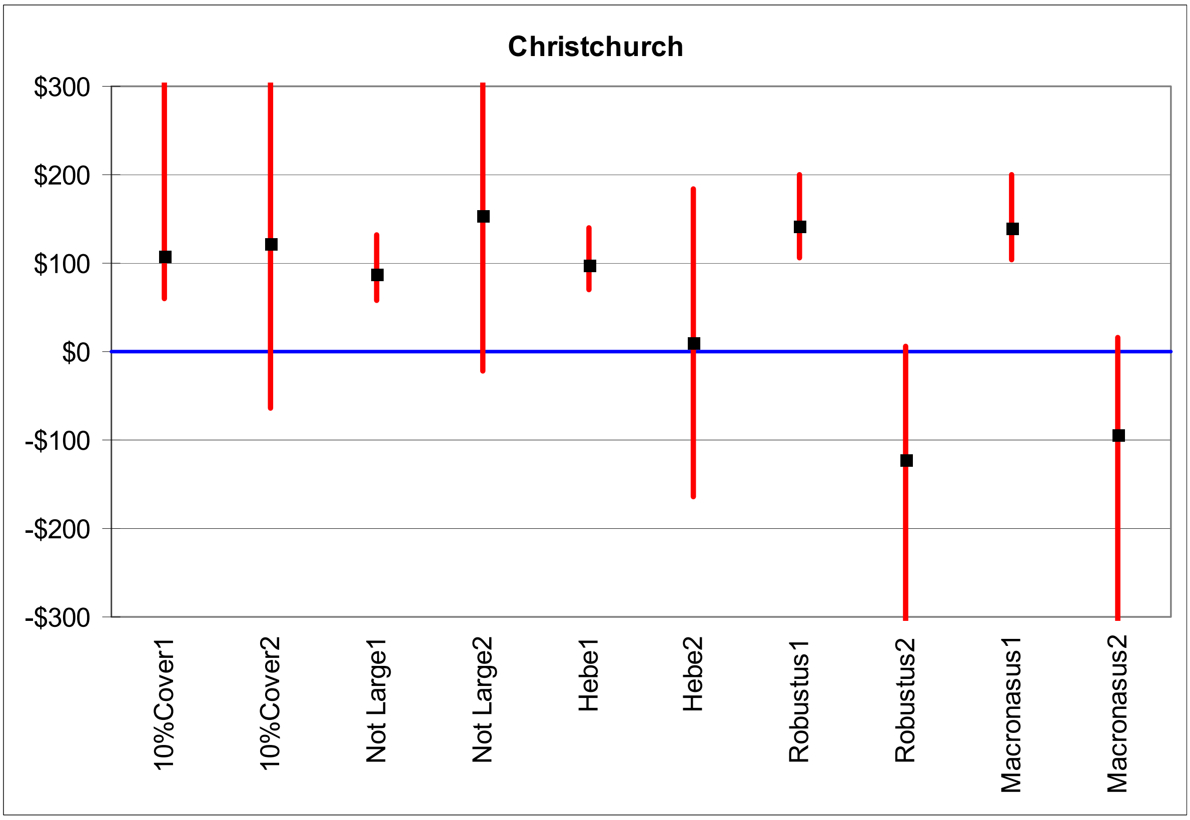


Figure 4.8: Timaru value profiles

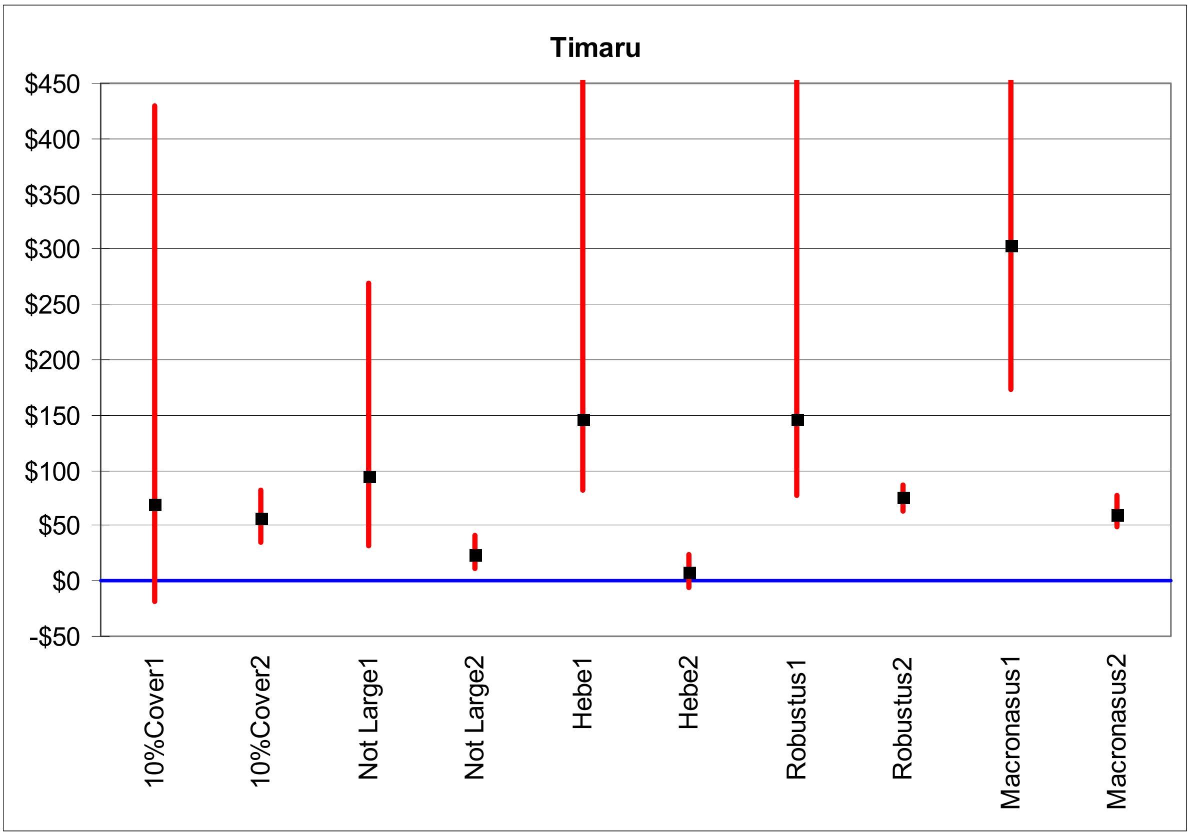
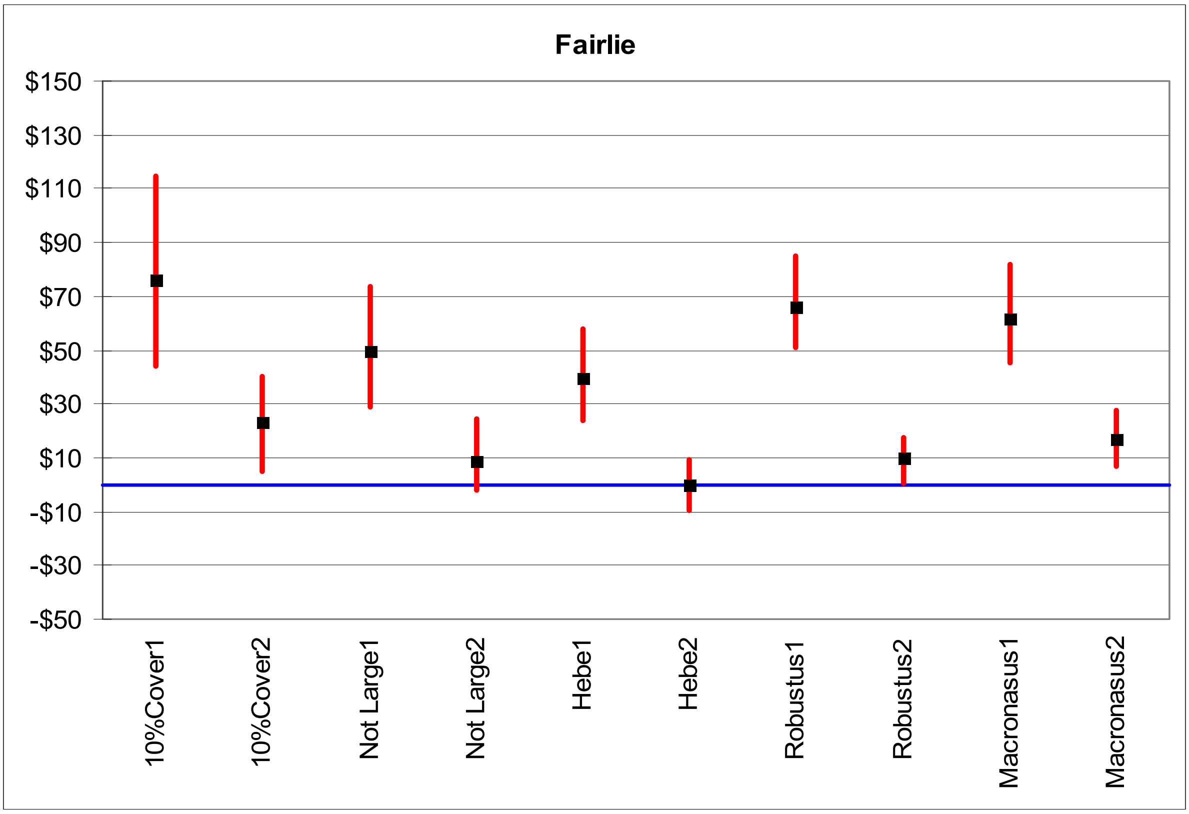


Figure 4.9: Fairlie value profiles



Chapter 5
Discussions and Conclusions

The results presented here indicate that members of the community, who were recruited without any knowledge of the topic of the investigation, were willing to engage in the choice experiment and were able to make a series of consistent choices that revealed their preferences about the outcomes of management of wilding pine trees in the Mackenzie Basin.

The use of schools to recruit community members to participate in group meeting-based surveys proved worthwhile. This process was quick and cheap, yet provided the opportunity to convey high quality background information to participants, and to train them in the choice experiment process in an interactive setting.

Very simple statistical models were able to explain a large proportion of the variance in people's choices. Statistical power was enhanced significantly by the use of two different models that allowed for respondent heterogeneity. While interactions models that accounted for individual characteristics were significant improvements over the basic model, they were not as good as the latent class models. The superior explanatory power of latent class models indicates the existence of at least two distinct groups of preferences within each community. Attempts to model class membership on the basis of personal characteristics were unsuccessful, indicating that the two types of tastes are not systematically related to particular sectors of the community.

The discussions held with focus group participants suggested that distant urban populations did not view wilding pines in the South Island high country as an issue of much relevance to them, raising the prospect of a significant distance-decay effect in values. Inspection of Figures 4.1 – 4.5 suggests that no such effect exists. In aggregate Twizel, Timaru and Christchurch money values were quite similar despite Twizel being located in the heart of the Mackenzie Basin, while Timaru and Christchurch are 1.5 and 3 hours drive away respectively. The only significant differences in values between locations were for Fairlie, which had significantly lower money values than other centres for preservation of each of the three endangered species. Fairlie Township is about 15-20 minutes drive from the Mackenzie Basin, although some of the participants lived much closer than that. Not withstanding differences between Fairlie and other groups, differences in values within communities are far more significant than differences in values between communities.

The finding of similar values in different communities was somewhat surprising given the focus group responses, which indicated that members of distant communities didn't view wilding pines as a problem that would have negative impacts on them, or which they should pay to remedy. This apparent anomaly may be explained by the different approaches adopted in the focus groups and in the surveys. In the focus groups care was taken not to lead or influence responses. The groups' primary foci were assessing the depth of existing knowledge about wilding pines. Once this information was collected, limited information was disseminated to the groups, but the potential immediate impacts of wilding pines on identifiable endangered native species were not conveyed. In contrast, the survey entailed provision of comprehensive information about the distribution, impacts and control of wilding pines, as well as information on the individual species at risk from wilding pine invasion in the Mackenzie Basin. Consequently, the benefits of wilding pine management were much more apparent in the survey and are likely to have been influential in shaping participants' responses. As a result, the values reported are not representative of values held now by the community, which has little understanding of what wilding pine trees are, let alone their potential impacts. Instead, the values reported here reflect the preferences of an informed community, such as might exist subsequent to an open debate about management options for wilding pines in the Mackenzie Basin.

The samples drawn here were not designed to be representative of each community, or for the selected communities to be representative of the whole of the South Island. However, it is possible to use the results to gain an understanding of the likely magnitude of values for protection of the three endangered species from extinction over the next 20 years. Consider *Hebe cupressoides*. The expected values for retaining the status quo Mackenzie Basin population of this species rather than for it to become locally extinct for the 4 different samples were $95 per household per year for five years (Christchurch), $71 (Twizel), $55 (Timaru), and $33 (Fairlie). Lower bound 95 per cent confidence limits for these 4 communities were $66, $38, $36 and $19 respectively.

Using the lowest expected value ($33 per year for 5 years) for illustrative purposes, and using a ten per cent discount rate to derive a present value, yields an estimate of $138 per household for maintaining the status quo for *Hebe cupressoides*. Aggregating this figure over approximately 300,000 households in the South Island yields a total present value benefit estimate in the order of $41 million. If the lowest 95 per cent confidence interval bound is substituted in this calculation the estimate becomes $24 million. Table 5.1 summarises results for the three endangered species.

Table 5.1: Value estimates

Species	Smallest annual expected value	PV @ 10%	Aggregate over 300,000 households	Smallest annual lower 95% confidence interval bound value	PV @ 10%	Aggregate over 300,000 households
Hebe cupressoides	$33	$138	$41 m.	$19	$79	$24 m.
Brachaspis robustus	$56	$234	$70 m.	$43	$179	$54 m.
Galaxias macronasus	$54	$225	$68 m.	$40	$167	$50 m.

Despite the conservative assumptions utilised in their construction, these value estimates indicate that the community is willing to spend extremely large amounts of money to protect these species. To overcome the inherently conservative approach adopted in Table 5.1, values from the mid-points of the ranges of expected values can be utilised (Tables 4.3 ~ 4.5). Using reasonable mid-range values of $70 (*Hebe cupressoides*), $120 (*Brachaspis robustus*) and $140 (*Galaxias macronasus*) yields aggregate values in the order of $50 m., $115 m. and $130 m., respectively. The value estimates derived here, combined with information on the costs of species preservation, whether by managing wilding pines or other methods, could form the foundations for cost-benefit analysis of species protection programmes.

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Appendix A

Introductory presentation contents

- Wilding pine trees defined
- Are wilding pine trees a problem or an asset?
- How wilding pine trees spread
- Spreading vigour
- Palatability
- Major areas of conifer spread in NZ
- Potential spread
- Where will pines spread/establish?
    - Canterbury
    - Mackenzie basin detail
- Impacts
- Prevention
- Rules about management
- Control methods
- Who is involved?
- Who pays?
- Control costs
- Some other important management issues in the Mackenzie Basin
- Bignose galaxias
- Robust grasshopper
- *Hebe cupressoides*
- Explanation of the choice experiment
- Descriptions of choice attributes
- Application of the choice experiment

Appendix B

Experimental design

Outcomes in Twenty Years:

Choice	Scenario	Coverage	Pattern	Hebe	Grass hopper	Fish	Cost
All	A	5%	Large	Extinct	Extinct	Extinct	None
1	B	10%	Scattered	OK	OK	OK	None
	C	2%	Large	Extinct	Extinct	Extinct	$100
2	B	5%	Small	Extinct	Extinct	OK	None
	C	5%	Small	OK	OK	Extinct	$100
3	B	2%	Large	OK	Extinct	Extinct	None
	C	10%	Scattered	Extinct	OK	OK	$100
4	B	5%	Small	Extinct	OK	Extinct	None
	C	5%	Small	OK	Extinct	OK	$100
5	B	10%	Small	OK	Extinct	Extinct	$25
	C	2%	Small	Extinct	OK	OK	$50
6	B	5%	Scattered	Extinct	OK	Extinct	$25
	C	5%	Large	OK	Extinct	OK	$50
7	B	2%	Small	OK	OK	OK	$25
	C	10%	Small	Extinct	Extinct	Extinct	None
8	B	5%	Large	Extinct	Extinct	OK	$25
	C	5%	Scattered	OK	OK	Extinct	$50
9	B	10%	Large	Extinct	OK	Extinct	$50
	C	2%	Scattered	OK	Extinct	OK	$25
10	B	5%	Small	OK	Extinct	Extinct	$50
	C	5%	Small	Extinct	OK	OK	$25
11	B	2%	Scattered	Extinct	Extinct	OK	$50
	C	10%	Large	OK	OK	Extinct	$25
12	B	5%	Small	OK	OK	OK	$50
	C	5%	Small	Extinct	Extinct	Extinct	$25
13	B	10%	Small	Extinct	Extinct	OK	$100
	C	2%	Small	OK	OK	Extinct	None
14	B	5%	Large	OK	OK	OK	$100
	C	5%	Scattered	Extinct	Extinct	Extinct	None
15	B	2%	Small	Extinct	OK	Extinct	$100
	C	10%	Small	OK	Extinct	OK	None
16	B	5%	Scattered	OK	Extinct	Extinct	$100
	C	5%	Large	Extinct	OK	OK	$50

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