Using Choice Modeling to Value Ecosystem Services on Arable Land[1, 2]

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Abstract: Many researchers have noted that not only natural ecosystems but also landscapes actively modified by humans (engineered or designed ecosystems) can significantly impact the level of ecosystem goods and service available thereby impacting on human and social welfare. In New Zealand, agriculture land is the largest area of engineered ecosystems on the national landscape. Study of the economic value of ecosystem services delivered by agricultural lands thus provides important insights into the management of engineered or designed ecosystems. This paper estimates values of ecosystem services, such as climate regulation, waste treatment, soil retention and scenic views, from land used for New Zealand's arable farming, using the contingent valuation method (CVM) and choice modeling.

Key Words**:** Environmental Valuation, Choice Model, Contingent Valuation Method, Cropping Land, Greenhouse Gas, Nitrate Leaching, Scenic Views

1. Introduction

Farmers use a variety of inputs including human and manufactured capital to produce food, fibre or raw materials. As well as human and manufactured capital, farmers also make use of natural capital inputs such as soil fertility, pollination, bio-protection, and groundwater. These latter inputs are examples of ecosystem services (ES). Some authors have classified ecosystem services into four categories: regulating, supporting, provisioning, cultural services (MEA, 2003). Food, fibre and raw materials are examples of provisioning ES. Several authors have noted that ecosystem services play major roles supporting or contributing directly to economic output including output from agriculture (Constanza et al., 1997; Daily et al., 1997; Heal and Small, 2002). It is clear that agriculture both benefits from and produces ES.

Income generation is a key objective for the majority of New Zealand farmers. Production of food, fibre and raw material generates revenue for landowners because food and fibre outputs can be sold in the market place. However, many ecosystem services delivered by arable farms have public good characteristics, there are no markets for them and hence no prices to users or revenue for producers of those ES. The absence of transparent property rights for ES can result in their importance being overlooked by decision makers. When that occurs, profit maximizing behaviour

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may not lead to welfare maximization. Under these conditions, farmers may apply high amounts of external inputs such as synthetic fertiliser, pesticides, irrigated water and other inputs if they focus on food production to achieve short term profit maximization. This focus on profit maximization may have harmful consequences for natural capital stocks such as soil fertility, soil quality, and future productivity of the land. Little attention may be focused by landowners on aesthetic qualities of the landscape, or recreation possibilities if these ES are not readily marketed.

In many high income countries, agriculture has become more intensive in the last few decades (PCE, 2004). In New Zealand the intensification of agriculture has raised concerns about some of the harmful effects it can have including high nitrate levels in groundwater, degradation of lowland streams and lakes, effects on fish availability and effects on greenhouse gas emissions (PCE, 2004; Hughey et al., 2004). These concerns have focused particularly upon dairy farming but other types of farming including arable farming have come to the attention. Arable farming in New Zealand has made increased use of nitrogenous fertilisers during the past decade and this external input intensification has lead to increased greenhouse gas emissions and leaching of nitrates into the groundwater. Moreover, conventional arable farming practices lead to losses of soil through wind and water erosion and tends to mine soil organic matter. There are few recreation opportunities on conventional arable farms and arable farming landscapes may provide little aesthetic interest if they are dominated by treeless monocultures.

Researchers have estimated the total economic value of ecosystem services (ES) provided globally by 16 biomes (Constanza et al., 1997). Average, but not marginal values per hectare, of each ecosystem service have been estimated in these studies and the average values per hectare are applied irrespective of location. Patterson and Cole (1999a, b) replicated the Constanza et al. (1997) study and estimated values for Waikato and New Zealand ecosystem services. The land cover classes used in the Waikato and New Zealand studies include horticulture, agriculture and cropping land. Patterson and Cole (1999a, b) argue that for arable land only five ecosystem services have positive economic values.

We contend that arable farming can provide a range of ecosystem services and benefits to society as New Zealand farmers seek to maximize commercial gain from food, fibre and fuel production. Finding ways to more accurately measure the value of non-marketed ecosystem services associated with arable farming is a challenge addressed in this paper. We report how we have used choice modeling and CVM to estimate the economic value of selected ecosystem services provided on New Zealand arable land. Our paper estimates the economic values associated with four key ecosystem services: climate regulation, waste treatment, soil retention and scenic views associated with New Zealand arable farming. Based on data collected in a nationwide mail survey, our study reveals New Zealand resident's willingness to pay for improving these ecosystem services and establishes "ideal" levels for these attributes. We comment on the likelihood that private sector arable farming in New Zealand will shift toward farming that will maximise the sum of ecosystem services.

2. CVM and Choice Modeling Theory

In this analysis, our primary aim is to assess marginal economic values of ecosystem services; hence we employ two stated preference techniques - CVM and choice modelling. CVM and choice modeling are increasingly being formulated in a random utility framework, which allows measurement of the values of non-market goods and services. If there are two alternatives in CVM, then generally the binary logit model is used. The binary distribution arises from the assumption that $\varepsilon = \varepsilon^j - \varepsilon^i$ is logistically distributed. The cumulative and density logistic functions are respectively as follows:

Cumulative Logistic Function

$$F(\varepsilon) = \frac{1}{1+\exp(-\rho\varepsilon)} \tag{1}$$

Density Logistic Function

$$f(\varepsilon) = \frac{\rho\exp(-\rho\varepsilon)}{(1+\exp(-\rho\varepsilon))^2} \tag{2}$$

where ρ is a positive scale parameter and $-\infty<\varepsilon<+\infty$. For convenience we generally make the assumption ρ =1(Ben-Akiva and Lerman, 1985).

The assumption is that ε is logistically Gumbel distributed (Type I extreme value distributed). Under this assumption, the choice probability for alternative i is given by:

$$\Pr(i)=\Pr\{U^i > U^j\} \tag{3}$$

$$= \frac{1}{1+\exp(-(v_i - v_j))} \tag{4}$$

$$= \frac{\exp(v_i)}{\exp(v_i)+\exp(v_j)} \tag{5}$$

The odds ratio in favor of alternative i, which is the ratio of the probability that the individual will choose the alternative i to the probability that he/she will not choose it, is as follows:

$$\frac{\Pr(i)}{1-\Pr(i)} = \frac{\exp(v_i)}{\exp(v_j)} \tag{6}$$

$$= \exp(v_i - v_j) \tag{7}$$

The logit, which is the log of the odds ratio, is given by:

$$\ln(\frac{\Pr_i}{1-\Pr_i}) = v_i - v_j \tag{8}$$

$$= \Delta v \tag{9}$$

To estimate the welfare impacts, i.e., willingness-to-pay, for a change from the status quo state (alternative j) of the world to the chosen state (alternative i), the following formula is used:

$$v^i (p^i,q^i,m-CV,z)+\varepsilon^i= v^j (p^j,q^j,m,z)+\varepsilon^j, \qquad (10)$$

where CV (compensating variation) is the income adjustment necessary to leave the individual as well off with bundle i as she was with bundle j.

Again, the indirect utility function has a linear form. When the function has (k-1) unknown parameters plus COST, a measure of individual's cost of choosing a new state (alternative i), we could denote the difference in the indirect utility function as

$$\Delta v = v_i - v_j \qquad (11)$$

$$=X^i\beta_k - X^j\beta_k \qquad (12)$$

$$=\beta_1+\beta_2 (x^i{}_2 - x^j{}_2)+ \beta_3 (x^i{}_3 - x^j{}_3)+ \ldots+ \beta_{k-1} (x^i{}_{k-1} - x^j{}_{k-1})+a(COST), \qquad (13)$$

$$=\beta_1+\beta_2 (\Delta x_2)+ \beta_3 (\Delta x_3)+ \ldots+ \beta_{k-1} (\Delta x_{k-1})+a(COST) \qquad (14)$$

where a is the marginal utility of income, or coefficient of COST attribute. From (8) and (14), the logit of choosing alternative i is:

$$\ln(\frac{\Pr_i}{1-\Pr_i}) = v_i - v_j = \Delta v \qquad (15)$$

$$=\beta_1+\beta_2 (\Delta x_2)+ \beta_3 (\Delta x_3)+ \ldots+ \beta_{k-1} (\Delta x_{k-1})+a(COST), \qquad (16)$$

where, COST (i.e., CV) is the welfare value (WTP) for changing alternative from i (new state) to j (status quo). The median WTP can thus be calculated at the point where the probability of the individual choosing alternative i is 50 percent ($\Pr_i$=.50), where the odds ratio becomes 1, and the logit becomes 1. In other words, median WTP is estimated when Δv=0. Under this condition, equation (15) is rearranged to:

$$\beta_1+\beta_2 (\Delta x_2)+ \beta_3 (\Delta x_3)+ \ldots+ \beta_{k-1} (\Delta x_{k-1})+a(COST)=0 \qquad (17)$$

Therefore, the CV can be written as:

$$CV=\frac{1}{-a}(\beta_1+\beta_2 (\Delta x_2)+ \beta_3 (\Delta x_3)+ \ldots+ \beta_{k-1} (\Delta x_{k-1})) \qquad (18)$$

3. Estimating Marginal Value using the Conditional Logit Model

If an individual chooses one alternative among several options, the multinomial logit model or the conditional logit model is used. With the multinomial logit model, the effects of the independent variables are allowed to differ for each outcome. Alternatively, with the conditional logit model, characteristics of the outcomes are used to predict the choice that is made (Long, 1997); the conditional logit model assumes that the characteristics of the choice itself determine choice outcome.

From equation (5), the probability of choosing alternative m from j alternatives is:

$$\Pr(m) = \frac{\exp(\rho v^{m})}{\Sigma_{j=1}^{J} \exp(\rho v^{j})} \tag{19}$$

Again the scale factor, ρ, is typically assumed to equal 1(Ben-Akiva and Lerman, 1985).

In the multinomial logit model, we assume that Pr(m) is a function of the linear combination of $x\beta_m$. The vector $\beta_{m=}(\beta_{0m\ldots}\ \beta_{km\ \ldots}\ \beta_{Km})$ includes the intercept β_{0m} and coefficients β_{km} for the effect of x_k on outcome m. Thus, the probability of choosing alternative m from J alternatives for the multinomial logit model is:

$$\Pr(m) = \frac{\exp(x_i \beta_m)}{\Sigma_{j=1}^{J} \exp(x_i \beta_j)} \tag{20}$$

The multinomial logit model can also be expressed in terms of the odds ratio, as was done for the binomial logit model in equation (6). The odds ratio of outcome m versus outcome n given x is:

$$\frac{\Pr(m)}{\Pr(n)} = \frac{\dfrac{\exp(x_i \beta_m)}{\Sigma_{j=1}^{J} \exp(x_i \beta_m)}}{\dfrac{\exp(x_i \beta_n)}{\Sigma_{j=1}^{J} \exp(x_i \beta_j)}} \tag{21}$$

$$= \frac{\exp(x_i \beta_m)}{\exp(x_i \beta_n)} \tag{22}$$

$$= \exp(x_i [\beta_m - \beta_n]) \tag{23}$$

Taking logs shows that the multinomial logit model is linear in the logit:

$$\ln(\frac{\Pr(m)}{\Pr(n)}) = x_i (\beta_m - \beta_n) \tag{24}$$

When we assume β_n =0, the equation for the comparison with outcome n simplifies to

$$\ln(\frac{\Pr(m)}{\Pr(1)}) = x_i(\beta_m - \beta_1) = x_i\beta_m \tag{25}$$

This format is equivalent to equation (16) for the binominal logit model. Therefore, the welfare estimation can be calculated the same way as the binominal logit model.

For the multinomial logit model, however, the coefficients differ for each outcome. The idea is hard to apply for the choice model, because we must assume that the impact of the attributes of environmental quality remain the same across all choice alternatives; only the attribute *levels* differ across the alternatives. In the conditional logit model, the coefficients for a variable are the same for each outcome, but the values of the variables differ for each outcome. Thus, the conditional logit model is employed to estimate CV for the choice model. In the conditional logit model, the predicted probability is:

$$\Pr(m) = \frac{\exp(z_{im}r)}{\Sigma_{j=1}^{J}\exp(z_{ij}r)}, \tag{26}$$

where z_{im} are the variables when the i th outcome is m, and γ_k is a single vector for z_k. The odds ratio of outcome m versus outcome n given x is:

$$\frac{\Pr(m)}{\Pr(n)} = \frac{\dfrac{\exp(z_{im}r)}{\Sigma_{j=1}^{J}\exp(z_{ij}r)}}{\dfrac{\exp(z_{in}r)}{\Sigma_{j=1}^{J}\exp(z_{ij}r)}} \tag{27}$$

$$= \frac{\exp(z_{im}r)}{\exp(z_{in}r)} \tag{28}$$

$$= \exp([z_{im} - z_{in}]\gamma) \tag{29}$$

Taking logs shows that the conditional logit model is linear in the logit:

$$\ln(\frac{\Pr(m)}{\Pr(n)}) = ([z_{im} - z_{in}]\gamma) \tag{30}$$

When we assume z_{in} = 0, equation (30) is:

$$\ln(\frac{\Pr(m)}{\Pr(1)}) = z_{im}\gamma \tag{31}$$

Since the format of this equation (31) is the same as the one for the multinomial logit model (equation 25), welfare estimates are generated by using the same process of welfare measurement.

Hanemann (1982) expressed the value of a welfare change as follows:

$$CV=(1/-a)\ [\ln\Sigma_{i\chi C} \exp(v^i)- \ln\Sigma_{i\epsilon C} \exp(v^j)], \qquad (32)$$

where v^j and v^i represent utility before and after the change, a is the marginal utility of income (the coefficient of the COST or price attribute), and C is the choice set of the individual. If there are three options (one being the status quo), an individual will compare these options and choose one, while trading off attributes. However, Boxall et al. (1996) argue that the CV format ignores substitutes. They show that the conditional logit formulation of the choice model incorporates substitution possibilities through the denominator of equation (26). In this sense, we can restrict equation (32) to only two choice levels (one being the status quo) in an attribute:

$$CV=(1/-a)\ [\ln \exp(v^i)- \ln \exp(v^j)], \qquad (33)$$

which reduces to:

$$CV=(1/-a)\ [\exp(v^i)- \exp(v^j)]. \qquad (34)$$

And thus the welfare measure can be determined by calculation:

$$CV=(1/-a)\ [v^i- v^j]. \qquad (35)$$

This equation is the same as equation (18).

4. Survey Experiment Methodology

In September 2004, pilot surveys were tested on students at Lincoln University and on randomly selected residents in both the South and North Island. In November 2004 a pre-survey card, survey booklet and cover letter, and a reminder post-survey card were sent to 3000 individuals selected from the New Zealand electoral roll using a random stratified sampling design. The sample was divided into two strata: 1500 persons were randomly selected from the Canterbury region (which contains the largest area of arable farming in New Zealand) and 1500 from the rest of New Zealand. As the survey experiment was designed to use both CVM and choice modeling techniques, two different survey formats, CVM and choice modeling were designed and 480 CVM surveys and 1020 choice modeling surveys were mailed to each stratum.

The response rates for the surveys are shown in Table 3. The overall effective response rate for the survey experiment was 36%. The response rate to the CVM survey was 35 % in both regions. For the choice modeling survey it was 39 % in Canterbury and 34 % in the rest of NZ.

Both the CVM and choice modeling surveys contained four sections: (1) general questions about the environment in New Zealand; (2) general questions about New Zealand farming; (3) specific questions about alternative management scenarios for cropping farming; and (4) questions about respondent's social characteristics and backgrounds. Except for the section on alternative scenarios for cropping faming, all questions were held constant between the two formats. Social characteristic questions asked respondents about their age (AGE), gender (GENDER), education

(EDU), income (INC), and residence in rural or urban area (UEB). The questions relating to the environment and farming are summarised in Table1 with the variables.

ES characteristics and attributes

The attributes of selected ES provided by cropping farming in New Zealand were explained to all survey respondents at the beginning of the section on alternative scenarios. Attributes discussed were greenhouse gas emissions, nitrate leaching, soil retention, and scenic views of cropping farms. Each attribute was presented to respondents as several discrete levels of delivery (see Table 2). For example, the attribute of greenhouse gas emissions from cropping farms was presented as having three discrete levels: 'big reduction' (50% reduction from the current emission level); 'small reduction' (20% reduction from the current emission level); and 'no change' from current emission levels. For the nitrate leaching from cropping farms, there were three levels presented to respondents: 'big reduction' (50% reduction in nitrate leaching to streams); 'small reduction' (20% reduction in nitrate leaching to streams); and 'no change' from current level of nitrate leaching to streams. The attribute of soil quality of cropping farms was limited to two levels: 'small change' (soils retain their organic matter and structure over 25 years) and 'no change' (continuation of the current slow rate of soil degradation). The fourth attribute, scenic views of cropping farms was also limited to two levels; 'more variety' (more trees, hedgerows and birds and a greater variety of crops on cropping farms) and 'no change' (maintain the current cropping farming landscape).

CVM and choice modeling formats

In the CVM survey (n=480), respondents were asked to choose one hypothetical policy option from two alternative scenarios (See Appendix 2A). The first scenario involved a 'big reduction' in levels of greenhouse gas emissions, but 'no change' in the other three attributes, and a specific $ amount charged to each household. The other scenario had 'no change' in all four attributes with no charge to a household.

The cost to the household, the payment vehicle, was defined as an additional annual payment to the regional council responsible for management of the environment over the next five years. The discrete range of costs alternatives given to respondents was NZ$10, $30, $60, and $100. As the CVM survey questionnaires were designed to contain only one dichotomous CVM question, four different versions of the CVM surveys were created, one for each cost alternative. For all CVM versions, open-ended questions were asked after the dichotomous questions for the first scenario. After these two questions, the respondents were asked for their ideal policy; ideal level of each attribute; and their willingness-to-pay for the ideal combination.

In the choice modeling surveys (n=1020), more complex questions were asked about alternative policies on cropping faming. As in the CVM surveys, before the choice questions, respondents were briefed about the four attributes of ecosystem services and associated cost to the household. In the choice questions, however, respondents were asked to select the option they favored the most out of the three options provided (See Appendix 2B). Each option contained the four attributes and the cost to the household with various levels of attribute combinations. Policy option 1 had a higher cost to the household than did Policy option 2, and Policy option 3 was designed as the status quo. Respondents were asked to answer similar types of choice questions (the choice set) multiple times. As there are three levels for the greenhouse gas emission and nitrate leaching attributes, two levels in the soil and scenic view attributes, and four levels in the cost to household, there are $2^2 x 3^2 x 4$ factorial designs (Louviere et al., 2000). For statistically efficient choice designs, a D-efficient design (Huber and Zwerina, 1996) excluding unrealistic cases (Terawaki et al., 2003) was adapted to each of the choice questions. Following the choice set questions, respondents were questioned about their ideal policies.

5. Results

The descriptive statistics of the four sample strata (choice modeling in Canterbury, choice modeling in rest of New Zealand, CVM in Canterbury, CVM in rest of New Zealand) are presented in Table 4. Chi-square tests indicate there are no significant differences in the social characteristics across the four samples. The binomial logit model was adapted to analyze the CVM data. For simplicity, no social characteristic variables were included. The results of the CVM study for both areas are shown in Table 5. In both samples, coefficients of COST are negative, which suggests that people are likely to accept the policy with lower cost to households. However, COST in the Canterbury sample and the model overall is insignificant, while for the rest of New Zealand it is found to be significant.

Choice modeling results were analyzed with the conditional logit model using effect codes (Louviere et al., 2000) for the four ecosystem service attributes. Definitions of the effect codes for attribute variables are presented in Table 6. The advantage of using effect codes over dummy variables is the ability to observe a respondent's comparison of one level with other levels in an attribute (Takatsuka, 2004).

Table 7 shows the choice modeling results, including that of alternative specific constants (A-01, A-02), which present unobserved factors on respondent's choice (Morrison et al., 2002). All variables are significant at the 0.05 level, except for A-01 and A-02 in the Canterbury sample, which indicates that higher costs to household are not significant for Canterbury resident's decisions on preferred policies. An analysis without A-01 and A-02 is presented in Table 8. All variables except COST are positive and significant, which can be interpreted as people are willing to pay for improvements in levels of all four of these attributes. Big reductions in greenhouse gas emissions and of nitrate leaching have large magnitude coefficients for both the Canterbury residents and those who live in the rest of New Zealand. On the other hand for both sample strata, the coefficients of scenic views are relatively lower than for the other variables.

Economic values for the various policy alternatives described in the survey are estimated by using equation 35 and the results are shown in Table 9. The CVM survey provides an estimation of a single policy value from one CVM question that involves a 50% reduction of greenhouse gas emissions. The choice modeling results, on the other hand, elicit economic values for six policy alternatives, because the model can estimate multiple policies simultaneously from multiple choice sets.

From the CVM samples, mean values of the policy for a 50% reduction of greenhouse gas emissions are NZ$192.51 and NZ$86.03 respectively. The value for the Canterbury sample derived from the CVM surveys is nearly double the value of the same policy from the choice modeling samples.

The results from the choice modeling both with and without A-01 and A-02 are similar. For Canterbury residents, the policy for a big reduction of greenhouse gas emissions is valued at $100.91 in the model with A-01 and A-02, which is the highest value among the six policy alternatives. The following policies are ordered from second highest to lowest: big reduction of nitrate leaching; small reduction of greenhouse gas emissions; small reduction of nitrate leaching; soil quality changes; and scenic view change. For the 'rest of New Zealand' sample strata, the highest valued policy is a big reduction in nitrate leaching, and the rank order of the remaining policies is: big reduction of greenhouse gas emissions; small reduction of nitrate leaching; small reduction of greenhouse gas emissions; soil quality changes; and scenic views changes. The order of respondent's willingness to pay for the six policy alternatives is the same in both samples with and without A-01 and A-02.

The survey questionnaires asked respondents about their ideal level of each attribute and ideal cost to their own household. The mean cost to households for their ideal policies were NZ$63.04 and NZ$55.25 for the Canterbury stratum and the rest of New Zealand respectively, and the distribution from choice samples in both areas are presented in Table 10. For both samples, respondent's most preferred levels are a big reduction of greenhouse gas emissions, a big reduction of nitrate leaching, small change in soil quality, and more variety in scenic views.

Economic values of the ideal levels of the policies are estimated using choice modeling. The results show that the willingness-to-pay for the ideal policy combination is NZ$245.02 for Canterbury and NZ$254.98 for the rest of New Zealand in the analysis with AS-01 and AS-02 (see Table 9).

6. Summary

The CVM study allowed us to estimate economic values for a significant reduction of greenhouse gas emissions from arable lands for people living in Canterbury (the region with most cropping farming) and for people from the rest of New Zealand. Compared to the choice modeling results, the values derived from the CVM study are higher for the same policy. The high value may be due to the insignificant COST variable in the CVM Canterbury sample, however, the value derived from the CVM for the rest of New Zealand also shows a larger value than the estimate derived from the choice modeling. There may be embedding issues; respondents may not have clear boundaries between ES attributes and hence may overestimate the value of a single attribute.

This concern also appears in the study of respondent's ideal policy. The mean stated ideal cost to household for their preferred policies are much lower than the mean values of the ideal policy estimated by the choice modeling. The choice modeling approach can estimate values of multiple attributes simultaneously. The assumption is that each attribute has own separate bundle and value. However, respondents seem not to behave in this manner in this study. It is an open question whether the values for the ideal policy derived by the choice modeling reflect people's true willingness to pay. This methodological issue requires further investigation.

The results of the choice modeling shows that people in both areas have high willingness to pay for a big reduction of greenhouse gas emission and nitrate leaching from cropping farms. People in Canterbury are more concerned about greenhouse gas emissions than they are about other attributes, but people in the rest of New Zealand are more willing to pay to improve water quality that is impacted by cropping farms. The value of maintaining soil quality is higher for Canterbury respondents than for the rest of New Zealand respondents. Greater public knowledge in Canterbury of wind erosion and soil quality issues may influence Canterbury residents to assign higher values for these items than is assigned by respondents from elsewhere in New Zealand. Values of scenic views on cropping farms are the lowest among the four attributes. This ecosystem service, which is not directly related to ecosystem functioning and is a public good, is likely to be ignored in management decisions on cropping farms. However the results show that on average people in New Zealand enjoy seeing cropping farm landscapes. This ecosystem service may provide a significant component of the total social benefits that are derived from New Zealand arable lands.

The results of this study provide some insights that may be useful in development of policies for cropping land use in New Zealand. However, the ES attributes studied have external effects beyond each arable farm's boundary and those effects are likely to be overlooked by arable farmers. Further study is needed to determine if land use policies relating to arable farming need modifying to achieve greater recognition of these ES. Similar research can be completed for other engineered ecosystems particularly for pastoral land (the largest land use in New Zealand) and for horticultural land particularly as these have recently become the subject of considerable public attention.

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Appendix 1

Table 1. Definitions of Variables

Variables	Definition
AGE	Age
GENDER	1 if male; 0 if female
EDU	1 if primary school; 2 if high school without qualifications; 3 if high school wit qualifications; 4 trade/technical qualification; 5 undergraduate diploma; 6 bachelors degree; 7 postgraduate
INC	5 if less than $10,001; 15 if $10,001 to $20,000; 25 if $20,001 to $30,000; 35 if $30,001 to $40,000; 45 if $40,001 to $50,000; 55 if $50,001 to $60,000; 65 if $60,001 to $70,000
URB	1 if residence in urban area; otherwise 0
ENVIS	Knowledge of environmental issues; 1 if don't know; 2 if very bad; 3 if bad; 4 if adequate; 5 if good; 6 if very good
AIR	Quality of New Zealand air: 1 if don't know; 2 if very bad; 3 if bad; 4 if adequate; 5 if good; 6 if very good
FWAT	Quality of New Zealand freshwater in rivers and lakes: 1 if don't know; 2 if very bad; 3 if bad; 4 if adequate; 5 if good; 6 if very good
GWAT	Quality of New Zealand groundwater: 1 if don't know; 2 if very bad; 3 if bad; 4 if adequate; 5 if good; 6 if very good
CWAT	Quality of New Zealand coastal water: 1 if don't know; 2 if very bad; 3 if bad; 4 if adequate; 5 if good; 6 if very good
SOIL	Quality of New Zealand soils: 1 if don't know; 2 if very bad; 3 if bad; 4 if adequate; 5 if good; 6 if very good
PEST	Compared with five years ago New Zealand pesticides and fertilizer management in agriculture; 1 if don't know; 2 if much worse; 3 if worse; 4 if no change; 5 if better; 6 if much better
GG	Compared with five years ago New Zealand greenhouse gas emission management; 1 if don't know; 2 if much worse; 3 if worse; 4 if no change; 5 if better; 6 if much better

Table 2. Definitions of Attributes on Arable Farms

Attributes	Levels	Definitions
Greenhouse Gas Emissions	Big Reduction	50% reduction from the current emission level
	Small Reduction	20% reduction from the current emission level
	No Change	Maintain current emission level
Nitrate Leaching	Big Reduction	50% reduction in nitrate leaching to streams
	Small Reduction	20% reduction in nitrate leaching to streams
	No Change	Maintain current nitrate leaching to streams
Soil Quality	Small Change	Soil organic matter and structure are retained over 25 years
	No Change	Maintain current slow rate of soil degradation
Scenic Views	More Variety	More trees, hedgerows and birds and a greater variety of crops on cropping farms
	No change	Maintain the current cropping farm landscape
Cost to Household	10; 30; 60; 100	Annual payment to a regional council for the next 5 years (NZ$)

Table 3. Response Rates

	Canterbury			Rest NZ			Total
	CVM	CHOICE	Subtotal	CVM	CHOICE	Subtotal	
Surveys	480	1020	1500	480	1020	1500	3000
Undelivered	15	20	35	17	31	48	83
Responded	163	391	554	160	334	494	1048
Response Rate	0.35	0.39	**0.38**	0.35	0.34	**0.34**	**0.36**

Table 4. Descriptive Statistics

	CHOICE-Canterbury		CHOICE-RestNz		CVM-Canterbury		CVM-RestNZ	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
AGE	52.02	15.85	53.69	15.59	51.71	15.98	49.25	15.54
GENDER	0.57	0.50	0.56	0.52	0.49	0.50	0.42	0.49
EDU	4.00	1.57	3.97	1.64	4.05	1.67	4.20	1.66
INC	55.81	33.09	60.51	35.20	53.38	32.86	51.08	32.85
URB	0.74	0.44	0.68	0.47	0.73	0.44	0.76	0.51
ENVIS	4.33	0.79	4.35	0.96	4.30	0.93	4.34	0.88
AIR	4.87	0.91	4.96	0.83	4.88	0.84	4.90	0.92
FWAT	4.43	1.02	4.27	1.01	4.44	0.91	4.17	1.03
GWAT	4.60	1.14	4.17	1.20	4.65	1.21	4.14	1.18
CWAT	4.46	1.05	4.48	1.04	4.45	1.10	4.41	1.04
SOIL	4.42	1.07	4.17	1.17	4.42	1.22	4.39	0.92
PEST	4.36	2.39	4.34	1.44	4.21	1.64	4.34	1.49
GG	4.09	1.41	4.05	1.31	4.02	1.45	3.82	1.45

Table 5. Binomial Logit: CVM

	Canterbury					Rest of NZ				
	Coeff.		Std.Err.	t-ratio	P-value	Coeff.		Std.Err.	t-ratio	P-value
CONSTANT	0.628	**	0.295	2.128	0.033	1.324	**	0.313	4.232	2.32E-05
COST	-0.003		0.005	-0.645	0.519	-0.015	**	0.005	-2.928	0.003
Number of observation	151.000					154.000				
Log likelihood function	-100.364					-95.928				
Log likelihood function (0)	-100.572					-100.371				
Chi-squared	0.416					8.885				
Significances	0.518					0.003				
McFadden	0.002					0.044				
Ben/Lerman	0.528					0.568				
Akaike I.C.	1.356					1.272				

* Siginificant at the 0.10 level
** Siginificant 0.05 level

Table 6. Effect Codes: Choice Modeling

Attributes	Variables	
Green House Gas Emissions	GGS	1 if small reduction ; 0 if big reduction ; -1 if no change
	GGB	1 if big reduction; 0 if small reduction; -1 if no change
Nitrate Leaching	NLS	1 if small reduction ; 0 if big reduction ; -1 if no change
	NLB	1 if big reduction; 0 if small reduction; -1 if no change
Soil Quality	SOIL	1 if small change; -1 if no change
Scenic Views	SV	1 if more variety; -1 if no change
Cost to Household	COST	NZ$10; $30; $60; $100

Table 7. Conditional Logit: Choice Modeling with ASC

	Canterbury					Rest of NZ				
	Coeff.		Std.Err.	t-ratio	P-value	Coeff.		Std.Err.	t-ratio	P-value
COST	-0.011	**	0.002	-5.889	3.897E-08	-0.013	**	0.002	-6.565	5.22E-11
GGS	0.084	**	0.046	1.824	0.068	0.176	**	0.049	3.552	0.0003822
GGB	0.479	**	0.055	8.638	2.887E-15	0.309	**	0.059	5.262	1.42E-07
NLS	0.222	**	0.052	4.246	2.178E-05	0.118	**	0.056	2.091	3.65E-02
NLB	0.358	**	0.051	6.992	2.712E-12	0.456	**	0.056	8.168	2.89E-15
SOIL	0.233	**	0.040	5.782	7.387E-09	0.194	**	0.043	4.493	7.01E-06
SV	0.088	**	0.034	2.559	0.010	0.072	**	0.036	2.006	0.045
A_01	0.132		0.207	0.637	0.524	0.602	**	0.224	2.687	0.007
A_02	0.145		0.131	1.102	0.270	0.479	**	0.142	3.374	0.001
Number of observation	2075.000					1809.000				
Chi-squared	190.352					163.220				
Log-likelihood	-2006.260					-1717.536				
R-squared Adj.	0.043					0.043				

* Significant at the 0.10 level
** Significant at the 0.05 level

Table 8. Conditional Logit: Choice Modeling without ASC

	Canterbury					Rest of NZ				
	Coeff.		Std.Err.	t-ratio	P-value	Coeff.		Std.Err.	t-ratio	P-value
COST	-0.011	**	0.001	-9.421	2.887E-15	-0.012	**	0.001	-9.350	2.89E-15
GGS	0.088	**	0.046	1.906	0.057	0.191	**	0.050	3.862	0.0001125
GGB	0.513	**	0.046	11.213	2.887E-15	0.421	**	0.049	8.593	2.89E-15
NLS	0.250	**	0.048	5.207	1.915E-07	0.194	**	0.052	3.712	2.06E-04
NLB	0.370	**	0.050	7.418	1.186E-13	0.497	**	0.055	9.116	2.89E-15
SOIL	0.252	**	0.035	7.197	6.157E-13	0.261	**	0.038	6.870	6.43E-12
SV	0.105	**	0.032	3.316	0.001	0.121	**	0.033	3.628	0.0002856
Number of observation	2075.000					1809.000				
Chi-squared										
Log-likelihood	-2007.174					-1723.427				
R-squared Adj.	0.043					0.040				

* Significant at the 0.10 level
** Significant at the 0.05 level

Table 9. Economic Values

	GG- 20% reduction	GG-50% reduction	NL-20% reduction	NL-50% reduction	SOIL-change	SV-variety	Stated Ideal	Estimated Ideal
CVM								
Canterbury		192.51					48.89	
Rest of NZ		86.03					59.08	
CHOICE (With ASC)								
Canterbury	60.52	97.36	74.95	87.73	43.49	16.43	63.04	245.02
Rest of NZ	50.72	60.96	53.10	79.03	29.81	11.08	55.25	209.92
CHOICE (Without ASC)								
Canterbury	62.42	100.91	78.77	89.70	45.68	18.99	63.04	255.28
Rest of NZ	67.89	87.27	74.80	100.40	44.13	20.50	55.25	254.78

GG - Greenhouse gas emissions
NL - Nitrate leaching
SOIL - Soil quality
SV - Scenic Views

Table 10. Ideal Policies: Choice Modeling

	GG	*%*		*NL*	*%*		*SOIL*	*%*		*SV*	*%*
No Change	414	0.07	No Change	297	0.05	No Change	708	0.12	No Change	2592	0.44
Small Change	2160	0.36	Small Change	1932	0.32	Small Change	5265	**0.88**	More Variety	3366	**0.56**
Big Change	3450	**0.57**	Big Change	3801	**0.63**						
Total	6024	1.00		6030	1.00		5973	1.00		5958	1.00

Rest of NZ

	GG	*%*		*NL*	*%*		*SOIL*	*%*		*SV*	*%*
No Change	321	0.06	No Change	204	0.04	No Change	696	0.13	No Change	2354	0.46
Small Change	1935	0.37	Small Change	1410	0.27	Small Change	4500	**0.87**	More Variety	2764	**0.54**
Big Change	2991	**0.57**	Big Change	3621	**0.69**						
Total	5247	1.00		5235	1.00		5196	1.00		5118	1.00

Appendix 2

A. A sample question in a CVM Survey

Please tick the option that you prefer:

	Option A	Option B
Greenhouse Gas Emission	Big Reduction	No Change
Nitrate Leaching	No Change	No Change
Soil	No Change	No Change
Scenic Views	No Change	No Change
Cost to Household ($ per year for next 5 years)	$60	$0

Option A ☐ Option B ☐

B. A sample question in a Choice Modeling Survey

Please tick the option that you most prefer:

	Option A	Option B	Option C
Greenhouse Gas Emission	Big reduction	No change	No change
Nitrate Leaching	Big reduction	Small reduction	No change
Soil	No change	No change	No change
Scenic Views	More variety	No change	No change
Cost to Household ($ per year for next 5 years)	$100	$10	$0

Option A ☐ Option B ☐ Option C ☐