Public willingness to pay for carbon farming and its co-benefits

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Abstract

Governments worldwide have implemented climate change mitigation policies that aim to encourage abatement by changing agricultural practices. In Australia, farmers can gain carbon credits for sequestering carbon or reducing emissions. In addition to mitigation, these 'carbon farming' activities often generate ancillary (co-)benefits, such as creating native habitat or preventing erosion. This paper presents results of an Australia-wide choice experiment, conducted to estimate community values for climate change mitigation and the co-benefits of carbon farming. Values for carbon farming benefits are shown to depend on respondent's opinions about climate change. Respondents who do not believe that climate change is happening have a lower willingness to pay for reducing Australia's greenhouse gas emissions than people who believe climate change is (at least partly) caused by human actions. On average, respondents' were willing to pay $1.13/Mt of CO_2-e reduction. Respondents were willing to pay around $19/ha increase in the area of native vegetation on farmland. Value estimates for reducing soil erosion were not significant. Our results demonstrate that the community benefits from carbon farming extend beyond their effects on climate change mitigation. Future policies should take these positive values for co- benefits into account.

Keywords

Carbon Farming Initiative, Australia, broad-acre farming, nonmarket valuation, choice modelling, climate change mitigation

JEL classifications

Q19, Q51, Q54,

AgEcon Search Field

Environmental Economics and Policy

Highlights

- We estimate public willingness to pay (WTP) for the benefits of carbon farming
- Results show that Australians have a positive WTP for increasing native vegetation on farmland
- Australians have a positive, but low, WTP for carbon storage in agricultural soils or vegetation
- Reducing soil erosion (an intangible co-benefit of carbon farming) was not significant in respondents' preferences
- We discuss the implications of our value estimates for climate change mitigation policies

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Introduction

Agriculture represents the dominant form of land use globally covering 38% of the world's land surface (Dale and Polasky, 2007). A rapidly growing world population and land scarcity is, however, forcing trade-offs between the provision of food, conservation of natural habitats, and mitigating climate change (Phalan et al., 2011). Agricultural landscapes are increasingly expected to deliver multiple environmental and social benefits (Duke et al., 2012) and agri-environment schemes, such as the Conservation Stewardship Program in the United States and the European Union's agri-environmental payments under the Common Agricultural Policy, illustrate a policy focus on multifunctional agriculture (OECD, 2012).

In Australia, agriculture accounts for over 50% of land use (ABS, 2013), and for approximately 15%[1] of total greenhouse gas emissions (Department of Environment, 2015). Nevertheless, there are opportunities for agriculture to mitigate these emissions and contribute to greenhouse gas (GHG) abatement. Some agricultural practices are estimated to have a significant GHG reduction potential, for example reduced tillage intensity, residue management, replanting native grasses and trees, improved fallow, or improved manure management (Smith et al., 2014). Because of its potential to mitigate GHGs, the agricultural sector is a core component of Australia's climate change abatement policies in the 'Emissions Reduction Fund' (ERF). The ERF builds on the former Carbon Farming Initiative (CFI) and provides economic rewards to farmers who take steps to reduce greenhouse gas emissions or increase carbon storage in soils or vegetation (Department of Environment, 2014). Under the ERF, sequestration of one tonne of carbon dioxide (or the avoided emission of this quantity) generates one carbon credit that is tradable in a voluntary market (DCCEE, 2012). The policy specifies what carbon farming practices ('methodologies') are eligible for carbon credits. The ERF operates as a reverse auction scheme. Under this scheme, farmers are invited to submit project bids that specify the carbon farming practices they are willing to undertake, and the required price per tonne of emissions reductions or sequestration to undertake the practice(s). The government then purchases

[1] Land use, land-use change and forestry are not included in this estimate.

the lowest cost projects. As of October 2015, over 16.5 million Australian carbon credit units had been issued to carbon farming projects (Clean Energy Regulator, 2015).

Carbon farming encompasses land-based management practices that either avoid or reduce the release of greenhouse gas emissions (e.g. through avoided deforestation), or promote active sequestration of carbon in vegetation and soils. Approved sequestration practices include the reintroduction of woody vegetation into landscapes, protecting native forests, new farm forestry plantations, or increasing soil carbon by reducing soil disturbance (e.g. through no till farming or increased stubble retention). Farmers can also choose to avoid emissions through early savanna burning, or through changing livestock feed (Department of Environment, 2014). Some of these practices present an opportunity to deliver environmental benefits other than climate change mitigation (Lin et al., 2013; Phelps et al., 2012). For example, increasing soil organic matter improves soil quality for cropping. Practices such as planting and/or seeding native species on cleared or partially cleared land or reducing the intensity of stock grazing could have co-benefits for biodiversity or landscape aesthetics (in addition to their GH abatement benefits). Some of the co-benefits from carbon farming will have social and environmental values beyond the private benefits to farmers. Many of such co-benefits are not traded in markets, and thus their monetary value is difficult to measure and compare (Elbakidze and McCarl, 2007). Carbon farming could however lead to profit losses for farmers despite selling carbon credits (Kragt et al., 2012). Even the production of co-benefits may not provide sufficient private incentive to a farmer to cover this loss. Ultimately, the potential to achieving co-benefits through carbon farming is contingent on the value the public places on these 'greater societal goods' and the degree to which the public is prepared to pay for them.

Previous studies provide evidence that people are concerned about climate change (Hine et al., 2013; Wicker and Becken, 2013) and are willing to pay for actions to mitigate carbon emissions (Daziano and Achtnicht, 2014; Kotchen et al., 2013). There is, however, a sparse body of literature on the value of co-benefits of climate change policy (Longo et al., 2012). Non-market valuation techniques that attribute a monetary value to non-market goods can be employed to estimate the benefits of carbon farming that are most valuable to the public. For example, Glenk and Colombo (2011) applied a choice experiment to elicit preferences and estimate benefits of a soil carbon sequestration programme in Scotland with a focus on the co-benefits for biodiversity (indicated as bird habitat). They found a high significance of the bird habitat attribute, indicating a preference by respondents for biodiversity improvements as a result of the soil carbon programme. MacKerron *et al.* (2009) explored consumer willingness to pay (using a choice experiment) for voluntary carbon offsets in an aviation context with different types of co-benefits, including "conservation and biodiversity by reforesting tropical rainforests to help preserve threatened and endangered species". Biodiversity was found to be a highly valued co-benefit. Both studies concluded that policy makers and carbon offset providers may be able to gain greater support for mitigation policies by emphasising co-benefits.

This study contributes to the literature by investigating public support for a large, national scheme that pays farmers to mitigate climate change through carbon farming. We use a choice experiment survey to estimate the willingness to pay for a reduction in carbon emissions, an increase in native vegetation, and a reduction in soil erosion associated with carbon farming practices. The rest of the paper is structured as follows. In the next section we describe the methodology used to assess the public's willingness to pay for the co-benefits of carbon farming. The results are given in Section three. Section four provides a discussion and conclusion.

2. Methods and Materials

2.1. Choice experiment survey design and administration

We estimated the Australian public's willingness to pay for the co-benefits from carbon farming using a choice experiment (CE) survey. CEs are theoretically based in Random Utility Theory and Lancaster's characteristic theory of value (Lancaster, 1966). A CE survey was designed based on information from peer-reviewed literature, grey literature, interviews with agriculture experts, focus groups with community members, and a pre-test conducted with 103 respondents. In the focus groups, the researchers discussed a range of potential carbon farming (co-)benefits, from which the most meaningful attributes were selected. Of the possible co-benefits and their levels identified through the literature review, expert interviews, and focus group discussions, area of native vegetation and erosion level were selected to capture public values for biodiversity and soil health respectively, in addition to climate change abatement benefits. Native vegetation was expressed as a percentage increase from the current level of native vegetation on farmland (29.8 million ha, about 7.4 percent of total farm area; ABS, 2011; EPA, 2007), and the corresponding number of hectares. Erosion levels were expressed as the percentage reduction from current levels (currently approximately 1,634 million tonnes per year; ABS, 2011; EPA, 2007), and the tonnes of soil erosion that are avoided per year. The final attributes, their levels, and descriptions are provided in Table 1.

In the first part of the survey, respondents were provided with a brief description of climate change and questions regarding their opinion on climate change. Respondents were asked if they think climate change is happening and who or what is responsible for the change. The respondents could choose from five options, which were based on other climate change perspectives studies conducted in Australia (Leviston et al., 2011). In the analysis, the answer options were effects-coded with -1 if respondents did not believe climate change is happening, 1 if they believed in human-induced climate change, and zero otherwise. In the second part of the survey, carbon farming was described to respondents. Information was provided on the Australia's carbon farming policies at the time, and what activities farmers could undertake to reduce atmospheric greenhouse gasses. It was explained that "changes made in farm management can have different environmental impacts. For example, 'carbon farming' can reduce greenhouse gas emissions or increase carbon storage. Carbon farming practices can also affect soil quality or increase habitat provision for native plants and animals." Respondents were told that "the environmental impacts of changed farm management depend on the ways policies are implemented, and the area over which a method is applied."

Table 1. Attributes, descriptions and levels as used in the survey

Attribute	Description	Levels
Annual net cost	Farmers will need to be compensated for the changes they make. This money will need to come from an increase in annual taxes for all Australians. The 'annual net cost' describes how much the policy would cost your household each year for the next 100 years.	\$0, \$20, \$50, \$150, \$300 per year
Emissions reduction / Carbon storage	The predicted reduction in Australia's net annual GHG emissions. Current Australian emissions are about 575 million tonnes of CO_2-equivalent (CO2-e) per year.	0, 2.8, 11.5, 20, 34.5 Mt CO2-e/year. This was compared to the percentage of Australia's emission reductions (0%-6%); and direct energy consumption by households (140K–2.4million).
Area of native vegetation	Increased area of native vegetation on farmland. The current area of protected native vegetation on farmland in Australia is 29.8 million hectares (ha).	0, 0.5, 1.2. 1.8 million ha. This was compared to the equivalent proportion of additional native vegetation on farmland (0-6.1%)[‡].
Soil erosion	Some environmental management practices can improve soil quality and decrease soil erosion. In 2011, soil erosion on farmland was approximately 1,634 million tonnes per year (t/yr).	0, 160, 300, 500 million t soil erosion per year. This was compared to the equivalent proportion of current erosion (0-30.6%)[‡].

[‡] There are some carbon farming practices that can increase native vegetation, such as regeneration of native forests; and environmental plantings. There are many carbon farming practices that can reduce soil erosion, such as stubble retention, no-till cropping, permanent pastures and other practices that increase groundcover.

Each choice question contained three alternatives (Figure 1). Alternatives 1 and 2 present hypothetical outputs from a carbon farming policy. Alternative 3 was a ‘status quo’ alternative under which no additional action would be taken and no environmental benefits would be generated. The carbon farming policy alternatives 1 and 2 would come at a cost to respondents. The levels of this cost attribute were designed to reach respondents’ choke price, based on the maximum that respondents in the focus groups and survey pre-test said they were willing to pay to achieve carbon farming co-benefits. In the survey, respondents were told that the costs are to be paid once each year for the next 100 years, if the policy is implemented. They were also asked to think about how much they can afford to pay and other ways they could spend their money, when answering the choice sets.

Impacts	Alternative 1	Alternative 2	Alternative 3 – no action
Emissions reduction / Carbon storage	20 Mt CO_2-e/yr (3.5 %)	2.8 Mt CO_2-e/yr (0.5 %)	No emission reduction or carbon storage
Increase in native vegetation	1.8 million ha (6.1 %)	1.8 million ha (6.1 %)	No increase in native vegetation
Reduction in soil erosion	500 million t/yr (30.6 %)	0 t/yr (0%)	No reduction in soil erosion
Annual net cost to your household	$300	$200	$0
My preference:	☐	☐	☐

Figure 1. Example choice question as used in the survey

The CE questions were structured using an S-efficient Bayesian design (Rose and Bliemer, 2005), with priors from a pre-test with 103 respondents. The complete design included 24 choice sets which were divided into four blocks so that respondents received six choice questions each. Respondents were randomly allocated to one of these blocks. The third and final part of the survey included follow-up questions regarding respondents’ agreement with and understanding of the information provided and socio demographic characteristics.

The survey was distributed online via a commercial research panel in March 2013. The online survey contained links to further information and data sources for carbon farming and the attributes. Sampling was targeted at Australian residents living in rural and urban areas. Equal proportions of respondents were sourced from New South Wales, Queensland, Victoria and Western Australia. Further, sampling targeted nationally representative distributions of age and education levels, and equal proportions of women and men.

2.2 Modelling approach

Multinomial logit (MNL) models have traditionally been used to analyse discrete choice data (Bennett and Blamey, 2001; Scarpa et al., 2007). Although the MNL model provides a computationally convenient choice model, it relies on the restrictive Independence of Irrelevant Alternatives (IIA) property, and has limited ability to capture individual preference heterogeneity. Socio-economic variables can be included in the specification of the utility function to assess how observable characteristics influence preferences across respondents, but there is no means to characterise unobserved preference heterogeneity. More recent modelling approaches, such as the mixed logit (ML) or latent class (LC) models, relax the IIA assumption and account for unobserved individual heterogeneity in the systematic component of utility (Hensher and Greene, 2003). Various authors (e.g. Louviere et al., 2002; Louviere and Eagle, 2006; Yao et al., 2014) identified the additional importance of accounting for differences in variance between individuals, which requires models that can represent unobserved individual heterogeneity in the random error component of utility.

For this study, mixed logit models were specified that included all environmental attributes as normally distributed random parameters[2], the cost attribute as a random parameter with a constrained triangular distribution, and an error component term that accounted for possible correlation between the errors of the first and second policy alternatives (rather than allowing similar error distributions as the status quo alternative). The ML models also accounted for the panel data nature of the model by allowing for error correlations between choices made by the same respondent. For more information about these models[3], the reader is referred to, for example, Hensher *et al.* (2005), Greene *et al.* (2006) or Hess and Daly (2014).

[2] A variety of distributional assumptions were tested, including fixed parameters, constrained triangular, normal and log-normal distributions. The models reported in this paper fitted the data best.
[3] The theoretical background and specification of the mixed logit model has been discussed in depth in previous literature (see Hensher et al. 2005).

3 Results

3.1 Respondent socio-demographic characteristics

Table 2. Socio-demographics of survey respondents (n = 929)		Census (2011)#
Gender		
Male	49.0%	49.4%
Female	51.0%	50.7%
Metro areas		
Urban	73.3%	70.2%
Peri-urban and rural	26.7%	29.6%
Education		
University degree	39.1%	14.9%
State		°
New South Wales	25.6%	32.2%
Queensland	24.9%	24.9%
Victoria	23.4%	20.2%
Western Australia	26.2%	10.4%
Age (years)		
Average	41.76	44.13
Standard deviation	14.55	
Range	18-83	

Population statistics from Australian Bureau of Statistics 2011 Census for NSW, QLD, VIC and WA. ° Proportion of the total Australian population.

The sampling process yielded 929 completed surveys for further analysis. Respondents who said that they did not believe the carbon farming policy scenarios, or who protested against paying for climate change mitigation through their taxes, were not included in the sample. A description of the sample is provided in Table 2. There were no significant differences in socio-demographic characteristics between respondents from different States, or between urban and peri-urban/rural respondents. Less than 2% of the sample (17 respondents) was employed in the agriculture and forestry sector. Compared to the Australian 2011 Census data (ABS, 2012), our sample was representative for gender and age distribution, but was more highly educated than average Australians (Table 2).

The majority of respondents (622; 67%) thought it was appropriate to encourage changes in rural land management to help reduce the risks of climate change. While 87 respondents (9.4%) did not think rural land use changes are an appropriate mitigation strategy, another 220 respondents were unsure. More than 90 percent of respondents believed that climate change is happening (Table 3). Of these, 67.6 percent thought humans are either causing or contributing to climate change.

Table 3. Respondents' opinions about climate change	# of resp	%
lon't think that climate change is happening (coded -1)	42	4.4
ave no idea whether climate change is happening or not (coded 0)	37	4.0
hink that climate change is happening, but it is a natural fluctuation in Earth temperatures (coded 0)	222	23.9
hink that climate change is happening, and that human actions are contributing to the change (coded 1)	491	52.8
hink that climate change is happening, and that human actions are causing it (coded 1)	137	14.8

3.2 Model results

A multinomial logit (MNL) model where observable respondent characteristics were interacted with the attributes was tested first (Appendix 1). These interaction terms allowed us to assess whether variation in preferences towards costs, carbon storage, native vegetation and soil erosion can be explained by the respondents characteristics. Much CE work has, however, demonstrated the importance of accounting for unobserved preference heterogeneity. We therefore estimated several mixed logit (ML) models to account for unobserved heterogeneity in respondents' preferences. These ML models significantly outperformed the MNL models, demonstrated by a higher log-likelihood and R-squared, and lower model information criteria. The best performing ML model is reported in Table 4. The MNL model with interactions and an attribute-only ML model are available in Appendix 1 for comparison.

Table 4. Results of ML model with interactions between attributes and socio-demographic variables

Variable	Coefficient	(se)
ASC (=1 for SQ)[a]	-4.897***	(0.300)
Costs	-0.041***	(0.002)
Native vegetation	0.513***	(0.113)
Soil erosion	0.001	(0.001)
Carbon storage	0.024***	(0.006)
Standard deviations of random parameters' distribution or limits of triangular Costs distribution		
Costs	0.040***	(0.002)
Native vegetation	0.626***	(0.138)
Soil erosion	0.003***	(0.000)
Carbon storage	0.029***	(0.003)
Socio-demographic variables (interacted)		
CC opinion[b] x Cost	0.010***	(0.001)
CC opinion x Native vegetation	0.246**	(0.126)
CC opinion x Soil erosion	0.001***	(0.000)
CC opinion x Carbon storage	0.023***	(0.004)
Education x Native vegetation	-0.260**	(0.125)
Age x Cost	0.000***	(0.000)
Age x Soil erosion[c]	0.000	(0.000)
Age x Carbon storage	-0.000**	(0.000)
Queensland x Cost	-0.004**	(0.002)
Western Australia x Cost[c]	-0.001	(0.002)
Error component	4.766***	(0.283)
Log-Likelihood	-4075.2	
# of observations	5568	
pseudo-R^2 [d]	0.307	
AIC/n	1.471	
BIC/n	1.495	

[a] 21% of observations was a choice for the status quo, 79% of choices was for one of the two alternative options. [b] CC opinion = climate change opinion (effect coded -1, 0, 1, see Table 3); [c] Interactions between age and soil erosion, and between WA and costs are kept in the model to allow comparison with the best performing MNL model (see Appendix 1); [d] Calculated against a constant only model LL_0 = -5909.7; ***, ** = significant at 1% and 5% level respectively; Standard error in parentheses.

The model that fits our data best is a ML model that incorporates unobserved and observed preference heterogeneity by including both random parameters for the attributes, and interactions between the attributes and observed socio-demographic characteristics (Table 4). There is a significant tendency for respondents to choose one of the carbon farming options over the no-cost status quo option, as indicated by the negative and significant coefficient estimates for the alternative specific constant (ASC). Consistent with *a priori* expectations, respondents prefer choice options that have lower costs, larger areas of native vegetation, and higher levels of carbon sequestration. The coefficient for reduced soil erosion is not significant, although preferences towards soil erosion vary considerably, as indicated by the significant standard deviation on the soil erosion random parameter. The standard deviations on the other attributes' random parameters are also significant at the 1% level, showing that there is substantial heterogeneity in preferences towards all attributes amongst respondents.

Opinions about climate change (Table 3) have a significant effect on respondents' attitudes to all of the choice attributes. Respondents who believe in human-induced climate change have a higher likelihood of choosing an option that has higher costs, more native vegetation, more erosion reduction, and more carbon storage than respondents who don't know or do not believe that climate change is happening, and respondents who believe climate change is a natural fluctuation in Earth temperatures. Other socio-demographic variables that explain heterogeneity in respondents' preferences are having a university education, age, and State. For example, older respondents have a lower disutility for costs, but also gain less utility from carbon storage, than younger participants. For the interactions variables between States (dummy-coded) and choice attributes, only the interaction between Queensland residents and the cost attribute was significant and negative. This shows that respondents from Queensland are less likely to choose alternatives with higher costs than respondents from the other three States (NSW, VIC, WA).

3.3 Willingness to pay results

The ML model from Table 4 was used to estimate respondents' willingness to pay (WTP) for the co-benefits of carbon farming actions. WTP was simulated using 10,000 Halton draws from the unconditional parameter distribution (i.e. using the standard deviations of the random parameters rather than standard errors of the parameter estimates). As such, the estimates shown in Table 5 take the preference heterogeneity between respondents into account.

Table 5. Median WTP estimates for carbon farming choice attributes

Attribute	Sample average	CC opinion = -1 (CC is not happening)	CC opinion = 0 (Don't know or CC is natural)	CC opinion = 1 (CC is at least partly caused by humans)
Native vegetation	19.16 (\$/ha)	5.26 (-23.7 – 47.9)	12.7 (-22.5 – 86.5)	23.0 (-155.6 – 270.2)
Soil erosion	NS	NS	NS	NS
Carbon storage	1.13 (\$/Mt CO_2-e)	0.035 (-1.65-1.74)	0.603 (-1.00 – 4.06)	1.433 (-8.36 – 15.7.)

Notes: Median WTP estimates using the average of all other socio-demographic characteristics. 95% confidence intervals in parentheses calculated from unconditional distribution of random parameter estimates (standard deviation). CC opinion = climate change opinion, NS = not significant

The second column in Table 5 shows the sample average WTP estimates for each attribute. On average, respondents are willing to pay \$19.2 per year for every hectare increase in native vegetation, and \$1.13 per year for every metric tonne reduction in CO_2-e. No WTP can be calculated for soil erosion prevention because of the insignificant coefficient estimates on the soil erosion attribute (Table 4).

The confidence intervals show the preference heterogeneity between respondents, and thus reflect the wide variation that exists in people's preferences. Using the simulated distributions[4] of the WTP estimates, we can estimate the proportion of respondents with a positive WTP to obtain the environmental attribute (native vegetation or carbon storage) or prevent environmental degradation (in the case of erosion). These distributions showed that 86.9 per cent of respondents are willing to pay for increased carbon storage, and 80.5 per cent are willing to pay for increases in native vegetation. About 67.7 per cent of respondents have a positive WTP for reducing soil erosion, however median WTP for soil erosion was not significantly different from zero.

In the remainder of Table 5 we present the WTP estimates for each attribute given climate change opinions. These estimates clearly show that respondents who believe human-induced climate change is happening are willing to pay more for the benefits of carbon farming.

[4] Graphical representations of the WTP distributions are available upon request from the authors.

4. Discussion and conclusion

Carbon sequestration on farms as promoted by the Australian Emissions Reduction Fund is an important aspect of climate change mitigation policy, receiving bi-partisan political support and surviving several changes in governments. Our results reveal general support for climate change mitigation action, with the do-nothing option being undesired by the surveyed public. Survey respondents have a positive WTP for carbon sequestration and native vegetation co-benefits. A first important conclusion to draw from our work is that Australians are likely to receive more welfare benefits from carbon mitigation activities that also provide environmental co-benefits (such as biodiversity). This means that carbon farming policies could potentially be broadened to capture co-benefits and not be restricted to solely carbon sequestration. Public incentives that aim to change agricultural land management could therefore include higher payments for carbon credits that generate additional environmental co-benefits.

We also found that respondents' attitudes varied across States. In general, respondents from Queensland and Western Australia had a lower WTP for improvements in the environmental attributes than respondents from Victoria and New South Wales. Queensland and Western Australia are traditionally the 'conservative' States in Australia, with economies that rely heavily on the resource sector (mining). Because of their reliance on extractive industries, respondents from these two States may have different attitudes towards environmental management than respondents from Victoria and New South Wales. Indeed, other studies have also found that values for environmental goods and services vary between respondents' locations (Bateman et al., 2014; Yao et al., 2014). Work by the authors is currently underway to investigate whether and how environmental attitudes vary across Australian States.

One may be tempted to directly compare the WTP estimates from Table 5 between attributes. However, native vegetation and carbon sequestration are measured in different units, which means that estimates cannot be directly compared. However, the parameter estimates from the ML model can be used to calculate *marginal rates of substitution* (MRS) between attributes. Because there may be a difference between carbon sequestration rates of native vegetation and non-native plantations (Paul et al., 2013), we estimated the mean MRS between native vegetation and carbon. Results showed that respondents were, on average, willing to give up about 10.7 Mt of CO_2-e for every hectare increase of native vegetation. This means that respondents in our survey will prefer native vegetation over mono-culture, non-native plantations, as long as the difference in sequestration rates between the two is no more than 10.7 Mt of CO_2-e per hectare. Biophysical research is needed to determine the carbon sequestration rates from native, biodiverse vegetation and mono-culture, non-native plantations, and the conditions under which such sequestration rates will occur.

It is worthwhile mentioning recent events in Australian climate change policy. A carbon price existed under the former Governments' Clean Energy Act 2011 (Parliament of Australia, 2011). The 2014-15 carbon price was set at $25.40 per metric tonne of CO_2-e, much higher than respondents' WTP for carbon sequestration estimated in this study. Thus, our results provide evidence that Australians would not be willing to pay the carbon price as set by the previous government. This may be partly reflected in the outcome of the September 2013 Federal election, in which a key driver for a change in Government was repealing this carbon price. In July 2014, the carbon price was repealed by the Australian Senate, although the CFI continues to exist as part of Australia's climate mitigation policies under the Emissions Reduction Fund.

Our survey found a high level of acceptance of human-induced climate change and that opinions about climate change influenced the respondent's attitudes to the choice attributes. The strong relationship between respondent's personal opinion regarding the validity of climate change and WTP is notable and indeed an important driver of WTP estimates. These results echo other findings in the literature, such as Wicker and Becken (2013) who find that individual concern about climate change is correlated with the uptake of direct and indirect pro-environmental behaviours. The observed relationship captures respondents who believed humans had 'caused' or 'contributed to' climate change. The WTP results could be reflecting a sense of individual responsibility in response to a global issue, which would understandably be felt more strongly by those who see themselves as contributing to the problem.

Despite being tested extensively in discussions with focus groups and experts during the survey development, the soil erosion attribute was not significant in explaining respondents' choices. Individuals clearly interpreted the attribute in different ways, indicated by the attribute's significant standard deviation of the random parameter. Such variance between individual's interpretation of survey attributes is potentially increased when the attributes being tested are complex, and temporally and spatially dynamic—as is the case for the processes of soil erosion and native vegetation restoration. Why then, is the estimated coefficient for vegetation significant, while soil erosion is insignificant? The stated support for an increase in on-farm native vegetation as a co-benefit of carbon farming could be attributable to the 'tangible' nature of tree planting, and human affinity with this activity (e.g. national Arbour Day celebrations, community restoration planting events, and the prevalence of local community land care groups). The presence or absence of vegetation in the landscape is also highly visible. In contrast, soil erosion is a much less tangible process that (when accelerated) has a number of negative consequences that may not be well understood by the community (e.g. loss of ability to produce food, dust storms, sedimentation of waterways leading to loss of aquatic habitat and reduction in water quality). This 'invisible' nature of soil erosion and its consequences for human wellbeing may explain why the soil erosion attribute did not return a significant result in our survey.

The establishment of native vegetation was illustrated to the survey respondents as mixed species plantings labelled as 'native Australian vegetation'. Interviews with focus groups showed that this representation of biodiversity co-benefits was most easily understood by respondents. Researchers may be tempted to link a preference for native (non-pastoral or horticultural) vegetation to a general support for native biodiversity. However, caution must be applied when inferring wider views around native plantings based on our findings. Most importantly, using native species for carbon farming does not necessarily equate to the creation of biodiverse habitat, nor does the creation of monocultures exclude the use of native species. For example, it is common practice in Australia to establish Mallee plantings (the use of only one species of Mallee gum (*Eucalyptus*), planted as a monoculture) for the purpose of carbon farming (Paul et al., 2013). Consequently, Mallee plantings represent the use of native vegetation but in a non-naturally occurring ecosystem. Our results cannot tell whether people perceive monoculture plantings to provide native biodiversity or not. In future work on this topic, we will explore if and how respondents perceive the differences between native vegetation and biodiversity rich habitat.

Our analysis focussed on the public's WTP for carbon farming co-benefits. We did not consider whether adopting carbon farming practices (and selling carbon credits) would profit individual farmers. A relevant question to consider in further work is under what circumstances individual farmers would gain or lose from changing their management practices and selling carbon credits. Such an analysis would require interdisciplinary teams to estimate the impacts of different agricultural practices on yield and climate change mitigation, and the subsequent whole-farm economic impacts of a carbon farming scheme. Several projects are currently underway to address this question (e.g. Dumbrell et al, 2015).

In conclusion, this study found that the Australian public has positive preferences for the benefits of carbon farming, a key Government policy for mitigating climate change. The information provided here provides support for other countries considering climate change abatement through agricultural policies. The results indicate that a policy which favours activities that produce co-benefits, such as increase the amount of native vegetation on farms, is likely to be more attractive to the public than one that doesn't. However, caution should be used in applying these findings to other locations, given there is heterogeneity in carbon farming support across geographical locations and individual characteristic, such as climate change attitudes and socio-demographic characteristics.

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APPENDIX 1 – Results of the multinomial (MNL) model with interactions, an attribute-only mixed logit (ML) model, and the ML model with interactions that is presented in the main text

	MNL model with interactions		Attribute only ML model		ML model with interactions	
Variable	Coeff.	(se)	Coeff.	(se)	Coeff.	(se)
ASC (=1 for SQ)	-0.931***	(0.066)	-4.71***	(0.301)	-4.897***	(0.300)
Costs	-0.008***	(0.001)	-0.017***	(0.001)	-0.0405***	(0.002)
Native veg	0.105**	(0.051)	0.800***	(0.079)	0.513***	(0.113)
Soil erosion	0.000	(0.000)	0.003***	(0.000)	0.001	(0.001)
Carbon storage	0.012***	(0.004)	0.026***	(0.002)	0.024***	(0.006)
Socio-demographic variables (interacted)						
CCop[a] x Cost	0.002***	(0.000)			0.010***	(0.001)
CCop x Native veg	0.321***	(0.057)			0.246**	(0.126)
CCop x Soil erosion	0.001***	(0.000)			0.001***	(0.000)
CCop x Carbon storage	0.018***	(0.002)			0.023***	(0.004)
Edu x Native veg	-0.151***	(0.054)			-0.260**	(0.125)
Age x Cost	0.001***	(0.000)			0.000***	(0.000)
Age x Soil erosion	0.000**	(0.000)			0.000	(0.000)
Age x Carbon storage	-0.000**	(0.000)			-0.000**	(0.000)
QLD x Cost	-0.002***	(0.000)			-0.004**	(0.002)
WA x Cost	-0.002***	(0.000)			-0.001	(0.002)
Standard deviations of random parameters' distribution or limits of triangular distribution						
Cost			0.017***	(0.001)	0.040***	(0.002)
Native veg			1.222***	(0.092)	0.626***	(0.138)
Soil erosion			0.003***	(0.000)	0.003***	(0.000)
Carbon storage			0.029***	(0.003)	0.029***	(0.003)
Error component			4.904***	(0.275)	4.766***	(0.283)
Log-L	-5239.1		-4259.8		-4075.2	
N	5,568		5,574		5,568	
pseudo-R^2 [b]	0.111		0.279		0.307	
AIC/n	1.887		1.532		1.471	
BIC/n	1.905		1.544		1.495	

[a] CCop = Climate change opinion; [b] Calculated against a constant only model LL_0 = -5909.7; ***, ** = significant at 1% and 5% level respectively; Standard error in parentheses.