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

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A B S T R A C T

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 cobenefits 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 cobenefits into account.

1. 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 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

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

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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 3. Section 4 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% 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 1634 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

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 (CO_2-e) per year.	0, 2.8, 11.5, 20, 34.5 Mt CO_2-e/year. This was compared to the percentage of Australia's emission reductions (0%–6%); and direct energy consumption by households (140K–2.4 million).
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%).[a]
Soil erosion	Some environmental management practices can improve soil quality and decrease soil erosion. In 2011, soil erosion on farmland was approximately 1634 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%).[a]

[a] 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.