What carbon farming activities are West Australian farmers willing to adopt?

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Abstract
Transferring carbon from the atmosphere into terrestrial sinks through carbon farming has been proposed as an important component in Australia's efforts to mitigate greenhouse gas emissions. We use a Best-Worst Scaling survey to determine which carbon farming practices mixed crop-livestock and cropping-only farmers in the northern wheatbelt of Western Australia would be most and least likely to adopt. The survey was distributed via grower groups in Western Australia in August 2013. Farmers had strong preferences for stubble retention and no-till cropping. The practices that farmers were least willing to adopt were applying biochar and applying mulch. Farmers ranked improved soil quality and reduced soil erosion as the most important potential co-benefits of carbon farming. The research outcomes are discussed with respect to the implications for Australia's broadacre cropping industry and Australia's greenhouse gas abatement policies.

Key words
Carbon sequestration, farming systems, land use, policy, stated preferences, Best-Worst Ranking

Introduction
The Australian agricultural industry is responsible for 16 percent of national greenhouse gas emissions (DCCEE, 2010). One option for agriculture to contribute to national GHG emission reduction targets is through carbon farming. Carbon farming refers to a range of land use and land management practices designed to reduce emissions from farming activities, or sequester carbon in natural sinks such as soil and vegetation (Smith et al., 2008). The policy initiative at the forefront of efforts to reduce GHG emissions from agriculture in Australia is the Carbon Farming Initiative (CFI, Parliament of the Commonwealth of Australia, 2011).

An understanding of farmers' willingness to adopt carbon farming practices is needed to aid successful implementation of the CFI and similar policies. There exists a rich literature on farmers' adoption of environmental management and conservation farming practices (e.g. Knowler and Bradshaw, 2007; Pannell et al., 2006) Factors that have been found to be important in farmers' decisions to change agricultural management practices include: the (monetary and non-monetary) investment costs of the new practice; the impacts of the new practice on farm profitability; whether the practice 'fits' in the current farming system; farmer's financial situation and personal values; the social context in which the farmer operates; and the public (co-)benefits generated by adopting the practice.

Potential co-benefits of carbon sequestration in agricultural soils are: improved soil structure, reduced erosion, improved soil moisture retention, and increased plant available water and nutrient storing capacity (Lal, 2004). Returning land to native vegetation will promote carbon sequestration and can contribute to reduced salinity, improved water quality and improved ecosystem service provision (e.g. George *et al*. 2012). This study investigates whether farmers are willing to participate in carbon farming in light of the potential co-benefits that carbon farming practices can produce and which of these co-benefits are most important to farmers. We use a best-worst scaling survey to determine what carbon farming practices broadacre, dryland farmers in the northern wheatbelt of Western Australia are most and least likely to adopt.

Best Worst Scaling
Best Worst Scaling (BWS) is a survey method that requires respondents to select, from a set of objects, the object that they most prefer, and the object that they least prefer (Finn and Louviere 1992). In this study, the objects were carbon farming practices. Respondents were asked to choose the practice they would be most, and the practice they would be least likely to adopt, relative to the other carbon farming practices offered in the choice set (see Table 1). The choice task was repeated over 12 sets that contained different combinations

of the practices. This repetition of varied choice sets yields the information needed to calculate the preference scores of each respondent (Finn and Louviere 1992; Jones et al. 2013).

Table 1. An example of a Best Worst Scaling choice set from this study

MOST likely to adopt	Carbon farming practice	**LEAST** likely to adopt
◯	Retain crop stubble	◯
◯	Apply biochar	◯
◯	Plant tree belts	◯
◯	Plant perennial pastures	◯
◯	Apply mulch to bare soil	◯
◯	Adopt no-till cropping	◯

Analysis of Best Worst Scaling data

The best and worst selections in the BWS sets are used to rank the preferences for carbon farming practices for the aggregated survey sample. Using either a counting or regression approach we can generate the same preference ranking order (Finn and Louviere 1992). The counting technique involves summing, for each item, the number of times it was chosen as the 'most likely to adopt' minus the number of times it was chosen as 'least likely to adopt' (Finn and Louviere 1992). These scores can be rescaled by dividing the best minus worst score by the sample size (Marti 2012). In this survey design, each item appeared 8 times across the 12 choice sets. Therefore, the individual best minus worst scores range from –8 to +8. A score of +8 tells us that the carbon farming practice was chosen as 'most likely to adopt' by every farmer in every choice set that it appeared in. A score of -8 means that the practice was chosen as 'least likely to adopt' by every farmer in every choice set that the option appeared.

Survey design and distribution

Nine carbon farming practices were presented in the BWS choice sets. These nine practices were chosen based on a literature search and information gathered in a series of expert interviews. To understand the factors that could affect farmers' preferences or willingness to adopt certain activities, the BWS choice sets were accompanied by questions designed to elicit farmers' attitudes and opinions on climate change, climate change policies, and carbon farming. The link to the online survey was distributed to members of three grower groups: the Mingenew Irwin Group, the Liebe Group, and the North East Farming Futures Group. Responses were collected between 3 August and 2 September 2013.

Results

The following survey results are based on the responses of 43 mixed crop-livestock farmers and cropping only farmers from the northern wheatbelt of Western Australia. The median age of respondents was 40. Close to 80 percent of respondents stated that their farm was their only source of income. The average mixed crop-livestock farm was 7,120 ha with 65 percent dedicated to cropping, 20 percent to livestock and 15 percent left as remnant bush or land set aside for conservation. For cropping-only farmers the average land area was 6,900 ha with 85 percent dedicated to cropping and 15 percent has been left as remnant bush or set aside for conservation[1].

Factors affecting the decision to adopt carbon farming practices

Farmers were asked to rank six potential co-benefits of carbon farming practices in order of importance in their decision to adopt or not adopt carbon farming practices (Table 2). Improving soil quality was ranked as the most important benefit (relative to the other potential benefits presented) by 73 percent of mixed crop-livestock farmers and by 77 percent of cropping-only farmers. Selling carbon credits and carbon storage/reduced emissions did not appear to be important drivers of the decision to adopt carbon farming practices (Table 2).

Farmers' preferences for practice adoption

The preference order for adopting the nine carbon farming practices is presented in Table 3[2]. The two practices that were chosen most often as 'most likely to adopt' by both cropping only and mixed crop-

[1] Descriptive statistics of the sample are available from the authors upon request

[2] Results obtained from the regression method yielded the same preference order. Results are available from the authors upon request.

livestock farmers were retaining stubble and adopting no-till cropping practices. For mixed crop-livestock farmers, applying mulch was chosen most often as the practice that the farmers were least likely to adopt. For cropping only farmers the least preferred practice was applying biochar.

Table 2. Relative importance that mixed crop-livestock farmers (left) and cropping only farmers (right) placed on six potential benefits from carbon farming. The most important benefit is ranked as number 1.

Mixed crop-livestock farmers	Cropping only farmers
1. Improving soil quality	1. Improving soil quality
2. Reducing soil erosion	2. Reducing soil erosion
3. Enhancing biodiversity on farm	3. Landscape aesthetics/appearance
4. Carbon storage/reduced carbon emissions	4. Enhancing biodiversity on farm
5. Selling carbon credits	5. Selling carbon credits
6. Landscape aesthetics/appearance	6. Carbon storage/reduced carbon emissions

Table 3. Best Worst Scaling results for mixed crop-livestock farmers and cropping only farmers. These results are based on the number of times each practice was chosen as 'best' (Best Total) and the number of times the practice was chosen as 'worst' (Worst Total).

Carbon farming practice	Best Total	Worst Total	Best-Worst Total	Re-scaled Best-Worst Total
Mixed crop-livestock farmers (number of observations = 720)				
1. Retain stubble	168	0	168	5.6
2. Adopt no-till cropping practices	107	9	98	3.3
3. Plant perennial pastures	13	14	-1	-0.0
4. Implement rotational grazing	18	26	-8	-0.3
5. Increase pasture area (by decreasing crop area)	9	34	-25	-0.8
6. Inter-crop with perennial pastures	6	41	-35	-1.2
7. Plant tree belts	15	59	-44	-1.5
8. Apply biochar	12	85	-73	-2.4
9. Apply mulch to bare soil	12	92	-80	-2.7
Cropping only farmers (number of observations = 312)				
1. Retain stubble after crop harvest	69	0	69	5.3
2. Adopt no-till cropping practices	60	0	60	4.6
3. Establish areas of native vegetation	11	12	-1	-0.1
4. Plant tree belts	2	12	-10	-0.8
5. Plant perennial pastures	1	15	-14	-1.1
6. Inter-crop with perennial pastures	1	18	-17	-1.3
7. Apply mulch to bare soil	3	27	-24	-1.9
8. Plant trees for harvest e.g. oil mallees	7	38	-31	-2.4
9. Apply biochar	2	34	-32	-2.5

Discussion

The carbon farming practices that were preferred by both cropping and mixed crop-livestock farmers were 'retain stubble after crop harvest' and 'no-till cropping practices'. The high preference for retaining stubble and no-till cropping are likely to reflect farmers' perceptions of the production co-benefits associated with these two practices. Stubble retention and no-till cropping have been found to positively impact soil quality, which can subsequently have a positive impact on crop yield (Lal, 2004). The relationship between production benefits and likelihood of adoption is further confirmed by respondents ranking 'improved soil quality' and 'reduced soil erosion' as the most important co-benefits to be derived from carbon farming. The willingness to retain stubble and adopt no-till cropping practices could also be attributed to the relative ease with which these practices can be included in standard broadacre farming operations. In comparison, practices that do not readily fit within the existing farm enterprise mix received lower adoption preference scores in our study. For example, applying biochar, applying mulch and establishing areas of native vegetation or tree plantings, were often chosen as the practices farmers' were 'least likely to adopt'.

Of the six potential co-benefits of carbon farming presented to farmers in the survey, the least important co-benefits were those related to the opportunity to generate carbon credits and reduce the net greenhouse gas balance of the farm system. This finding strengthens our assumption that practices with benefits for farm producitivity are most likely to be adopted. Of course, farming systems vary between regions, as do the costs and benefits of changing agricultural practices. If we aim to achieve widespread adoption of carbon farming practices we will need two things: (1) a good understanding of the implications of carbon farming practices on agricultral production, and (2) flexible policies that allow farmers to select the carbon farming practices that are most appropriate for their farm system and their management strategy (Jones et al., 2013).

The challenge for farmers interested in carbon farming, is to know how much it will cost them to implement carbon farming activities. It is unlikely that farmers will participate in a carbon farming related policy such as the Carbon Farming Initiative or the newly introduced Emissions Reduction Fund if the costs are too high or benefits too low. The current study focussed on farmers' willingness to adopt carbon farming practices. The next step is to assess what carbon farming practices are able to deliver low-cost emissions reductions. Further research is ongoing to determine the whole-farm costs and benefits of different carbon farming practices.

Conclusions

In this study we collect information about the factors that affect farmers' decisions to adopt carbon farming practices. For a range of practices, we rank their preferences from 'most willing'' to 'least willing' to adopt. This study was done in light of increasing interest in agriculture as an industry that can reduce or offset greenhouse gas emissions. Our findings indicate that the motivating factors in the adoption of carbon farming practices are resource (soil) improvements and potential production benefits. As a result, it is not surprising that the practices farmers are most willing to adopt are retaining stubble and no-till cropping practices. It appears that and providing farmers with compensatory payments and additional information about the potential benefits of carbon farming activities is necessary to increase participation in policy schemes such as the Carbon Farming Initiative.

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