

RESEARCH ARTICLE

# Producer Willingness to Accept Incentive Levels for Cover Crop Adoption in the Southern Great Plains

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## Abstract

The purpose of this study is to analyze agricultural producers' willingness to adopt regenerative cover crop practices in their operation and the effects of producer and farm characteristics on willingness to accept (WTA) values. The paper utilizes the double-bounded contingent valuation method to analyze survey responses submitted by producers and non-operating landowners in the Texas and Oklahoma portions of the Southern Great Plains. Results showed an average WTA of \$26.38/acre for producers to adopt cover crops and that programs aimed at increasing adoption rates may require more substantial investment compared to those focused on continuity with current adopters.

**Keywords:** Contingent valuation; cover crops; incentive programs; regenerative/sustainable agriculture; southern great plains; willingness to accept

**JEL classifications:** C21; D00; Q1; Q15; Q18

## Introduction

The agricultural sector is gradually incorporating regenerative and climate-smart practices as a means to mitigate the deleterious effects of a changing climate and to sustain production capacity into the future. Despite prior research showing that regenerative practices such as cover cropping can yield numerous benefits, there is a lack of widespread adoption of such practices among U.S. producers (Clay et al., 2020).<sup>1</sup> With commodity and livestock production becoming increasingly vulnerable to the effects of climate change, the agricultural industry has a need to promote and implement regenerative practices to guarantee and intensify production for future generations. The massive scope and reliability of agriculture to weather constraints firmly places the sector as one of the most susceptible to the negative impacts of a changing climate (Malhi, Kaur, and Kaushik, 2021). This liability has concurrently intensified pressure on agricultural producers and their operations to maintain food security needs and prevent further degradation of natural resources while also facing unstable economic conditions and growing demand (Key et al., 2019; Piñeiro et al., 2020; Dohlman et al., 2024; Sands et al., 2023). While the definition of regenerative agriculture is not widely agreed upon among scholars and practitioners, the focus in this article is a combination of the process and outcome dimensions of regenerative agriculture. Specifically, how the implementation of a regenerative process (e.g., cover cropping) may generate beneficial

<sup>1</sup>Less than 5% of total cropland in the U.S. was planted to cover crops in 2022 (U.S. Department of Agriculture, 2024a).

outcomes in the form of ecosystem services for agricultural producers (e.g., additional soil water retention, soil carbon sequestration, reduced erosion, etc.) (Gosnell *et al.*, 2019; Newton *et al.*, 2020).

Using cover crops in place of bare fallow periods can be used to promote numerous benefits for soil health such as erosion protection, increase soil organic matter, reduce soil compaction, and stabilize or increase soil organic carbon (Bergtold *et al.*, 2019; Lewis *et al.*, 2018; Snapp *et al.*, 2005). Adoption of cover cropping is influenced by a range of perceived factors by producers. For instance, Wang *et al.* (2020) found that compared to short-term users of cover crops, those who have used the practice for 10 or more years perceived an increase in profitability from adopting cover crops. Short-term users may not perceive an increase in profitability, but producers may continue to adopt cover cropping due to perceived long-term benefits such as improvements in soil health and reduction in erosion (Plastina *et al.*, 2020; Wang *et al.*, 2020). Although cost share programs and incentive payments are designed to ease the financial burden of adopting conservation practices (i.e., cover cropping), Wang *et al.* (2020) found producers who received cost share to offset initial expenses did not indicate a higher perceived profitability compared to self-funded producers. Additionally, producers may be likely to discontinue the use of cover crops when they perceive additional costs and management difficulties to be associated with adoption (Dunn *et al.*, 2016). Despite these challenges, the findings underscore the importance of understanding producers' varied perceptions of cover cropping to effectively tailor strategies aimed at increasing adoption.

The adoption of certain practices has also shown to be affected by various producer demographic and farm characteristics. Lu *et al.* (2022) found that both higher levels of education and larger farm size were positively associated with adoption of conservation practices. Producer behaviors of prior conservation practice use or current use were also predictors of actual adoption of additional conservation practices. A more thorough understanding of these dynamics is essential for the development of effective incentives and policies that encourage broader adoption of these practices among producers. Producers also consider different factors when making their initial adoption decision compared to the intensity in which the practice is implemented, and creating clear pathways for scaling cover cropping will require addressing these diverse factors, ensuring that tailored incentives are in place to meet the unique needs and circumstances of different producer groups (Thompson *et al.*, 2021). Additionally, Bergtold *et al.* (2012) found that producers who rent their land are less likely to adopt cover crops while those who irrigate their crops and perceive more environmental benefits from cover cropping are more likely to adopt the practice. This prior research in adoption of conservation practice suggests that both producer demographic factors and various farm characteristics are crucial in shaping producer decisions regarding adoption of certain practices.

Total acres planted to cover crops in the U.S. increased 50% from 2012 to 2017, and the 2022 Census of Agriculture shows a 17% increase from 2017 to 2022 though much of the increased use of cover crops remains isolated to the Eastern United States (Wallander *et al.*, 2021; U.S. Department of Agriculture, 2024a; U.S. Department of Agriculture, 2024b). However, many producers remain hesitant to adopt this practice because of associated costs and uncertainties (Plastina *et al.*, 2018). Direct costs associated with adopting cover crops may include seed, planting, termination, and additional equipment while indirect costs include heterogeneous effects on following cash crops and foregone opportunities (Bergtold *et al.*, 2019). These costs will also vary depending on site-specific farm characteristics, cover crop variety, cost-sharing support programs, and other exogenous impacts such as precipitation and related weather conditions. Conservation programs such as the Environmental Quality Incentive Program (EQIP) and the Conservation Stewardship Program (CSP) along with various state and private programs provide supplemental economic incentives for qualifying producers utilizing cover crops, but economic savings are contingent upon factors such as the variety of cover crop and variable input prices. For example, EQIP funding for producers can cover up to 75% of the total cost of implementing conservation practices and the Natural Resources

Conservation Service (NRCS) estimated the cost of implementing a basic (organic and non-organic) cover crop in Texas at \$33.74/acre for the 2022 fiscal year (Park et al., 2022; Natural Resources Conservation Service, 2022).<sup>2</sup> Based on separate state guidelines, eligible producers enter a contract and implement the EQIP plan developed by both the NRCS and the producer, and payment rates for conservation practices are evaluated and determined each year within the fiscal cycle for separate states (Park et al., 2022). Although cost-share funding may influence the financial viability of adopting cover crops, producers may still face additional expenses and risk from adoption coupled with uncertainty regarding their net returns.

While certain benefits may be realized through the adoption of cover cropping, previous research has highlighted the associated risk of the practice and shown mixed outcomes regarding net returns to producers. Net returns with cover cropping are affected by several factors, including: the type of cover crop, timing of planting and termination, employed management practices, and local climate and soil conditions. Studies have shown that even with cost-share programs and feedstock savings for integrated crop-livestock operations, the financial gains from cover cropping are generally insufficient to offset incurred expenses resulting in negative net returns, especially in the initial years of adoption (Plastina et al., 2023; Thompson et al., 2020).<sup>3</sup> Moreover, variable yield impacts on subsequent cash crops and added opportunity costs of managing an additional crop in the absence of fallow periods introduce additional risk to producers that may hinder wide-scale adoption of cover cropping (Boyer et al., 2018; Plastina et al., 2020; Deines et al., 2023). Consequently, while cover cropping may provide potential long-term advantages, the economic challenges to producers in the short-term and concurrent risks may impede more extensive adoption of the practice.

In addition to valuable on-farm and economic benefits for producers, cover crops can also contribute to positive societal benefits through reductions in negative externalities (e.g., water nitrification and biodiversity loss). Established row-cropping and monoculture systems not only contribute to soil erosion and loss of soil nutrients, but also promote negative environmental outcomes such as water pollution from chemical leakage (e.g., nitrogen fertilizer) (Carlson & Stockwell, 2013; Paudel & Crago, 2021). Previous research has suggested that the use of cover crops on agricultural lands could lead to a reduction of nonpoint-source pollution from agricultural sources by reducing runoff, sediment loss, and nitrate leaching by utilizing residual nitrogen and water inputs (Blanco-Canqui, 2018).

Though the advantages of utilizing cover crops are widely known and recognized by soil and water conservation communities, the percentage of cropland planted to cover crops remains limited in the Southern Great Plains Region of the U.S. while the practice remains more prevalent along the eastern coast of the country (U.S. Department of Agriculture, 2024b). For example, Texas experienced the largest absolute increase in acreage planted to cover crops from 2017 to 2022, but higher adoption rates are relatively isolated to regions where irrigation is more prevalent (e.g., the Texas High Plains that sits above the Ogallala Aquifer) (U.S. Department of Agriculture, 2024b).<sup>4</sup> Adoption of cover cropping remains limited on dryland production systems in the Great Plains because of limited precipitation and the use of fallow periods to conserve soil moisture (Obour et al., 2021). While many research efforts have highlighted the positive outcomes associated with cover cropping the barriers to adopting the practice for agricultural producers are far less emphasized. In this context, this study aims to evaluate how various personal demographic and farm characteristics affect cover crop adoption and explore strategies to overcome adoption

<sup>2</sup>Historically underserved farmers may see up to 90% of the costs of implementing a conservation practice covered (Park et al., 2022).

<sup>3</sup>Plastina et al. (2023), Bowman et al. (2022), and Bergtold et al. (2019) explain that returns were highly variable and positive net returns are also possible, but dependent upon factors such as level of cost-share, resulting cash crop yield impacts, and timing of cover crops.

<sup>4</sup>From 2017 to 2022, the adoption rate of cover crops increased from 3.45% to 5.56% in Texas and 2.92% to 3.77% in Oklahoma, respectively (Sawadgo & Plastina, 2022; U.S. Department of Agriculture, 2024a).

8. Would you accept \$10.00 per acre to implement a cover crop in your operation?
- Yes – Please answer Question 8a.
- No – Please answer Question 8b.
- 8a. If you answered “**yes**” to the previous question 8 above, would you accept \$5.00 per acre *instead* to implement a cover crop?
- Yes
- No
- 8b. If you answered “**no**” to the previous question 8 above, would you accept \$15.00 per acre *instead* to implement a cover crop?
- Yes
- No

Figure 1. Example of contingent valuation questions.

constraints. Specifically, the objective of this research is to evaluate the minimum payment levels for adoption of cover crops in the Texas and Oklahoma portions of the Southern Great Plains (SGP) using a double-bounded contingent valuation model.

## Data

The data for this research was obtained through mail surveys sent to agricultural producers and landowners from the USDA FSA Farm Payment Files narrowed by county within the project region of Texas and Oklahoma. The survey was mailed out in two separate rounds for the data collection process. The first round was mailed to 1,500 people on May 16, 2022, with a 19.2% overall response rate, and the second round was mailed to an additional 1,500 people on December 9, 2022, with a 26% overall response rate. The survey contained six main sections: (1) farm characteristics; (2) cover crop adoption potential; (3) barriers to adoption of cover crops; (4) reasons producers use cover crops; (5) cover crop species and varieties; (5) approaches to overcoming barriers to adoption; and (6) personal demographics. A screening question was presented at the beginning of the survey to ensure participants were willing to complete the survey to guide subsequent research and extension activities. After removing incomplete responses from both rounds of the survey distribution, a total of 193 usable responses were recorded and 84 were utilized for the WTA analysis after removing those responses who failed to complete the double-bounded contingent valuation questions.

The WTA questions were designed based on the double-bounded contingent valuation method which allows respondents to engage in two rounds bidding to minimize the intervals of their true WTA values. To provide a wider range of offers to participants, three versions of the survey were distributed with each version containing different offers for the WTA questions. Specifically, the initial bid values used in the three versions of the survey were \$10/acre, \$20/acre, and \$30/acre., and an example of the contingent valuation questions is presented in Figure 1. Distributing three versions of the survey, each with different offers, helps account for the variability of cost-sharing support program contracts and estimation of the entire distribution of WTA values more accurately. The initial bid values used in the survey were derived from the EQIP estimated cost of \$33.74/acre for implementing a basic cover crop in Texas for the 2022 fiscal year (Natural Resources Conservation Service, 2022). These bid values were then calculated by applying 33%,

66%, and 100% cost-share scenarios, with the resulting amounts rounded for simplicity across the three survey versions.

**Methods**

The contingent valuation method is a nonmarket valuation technique and is commonly employed to derive monetary values for non-marketed goods and services. Contingent valuation methods routinely utilize dichotomous choice questions to elicit WTA values (Shrestha & Alavalapati, 2003; Geleto, 2011; McGurk et al., 2020). These questions involve asking respondents to answer a simple yes or no question about accepting a previously determined amount for a specific program, service, or other nonmarket goods. The respondents will state their preference (e.g., if they will adopt a practice if they are offered X amount of dollars) for the presented alternatives. The double-bounded method has been adopted by many researchers because estimates can be improved upon compared to the single-bounded method when respondents engage in two consecutive rounds of bidding (Hanemann et al., 1991; Kanninen, 1993; Riddel & Loomis, 1998). Considerably more statistical evidence is revealed by the follow-up bid, which is based on the response to the first bid, and gives asymptotically more efficient gains compared to the single-bounded method (Hanemann et al., 1991).

The following econometric framework from López-Feldman (2012) has been adapted for estimating WTA using simple modifications. The model involves dichotomous variables, denoted as  $y_i^1$  and  $y_i^2$ , representing responses to two close-ended questions. For example,  $y_i^1 = 1$  and  $y_i^2 = 0$  indicate “yes” to the first question and “no” to the subsequent one, and the probability that an individual responds yes to the initial question and no to the following question is expressed as  $Pr(y_i^1 = 1, y_i^2 = 0|z_i) = Pr(y, n)$  where  $y$  represents “yes” and  $n$  represents “no” (the conditional probability on explanatory variables is foregone for generality). Respondent  $i$ ’s WTA can be written as follows:

$$WTA_i(z_i, u_i) = -z_i'\beta + u_i \text{ and } u_i \sim N(0, \sigma^2) \tag{1}$$

Here,  $z_i$  represents a vector of explanatory variables,  $\beta$  is a vector of parameters, and  $u_i$  is the error term (López-Feldman, 2012). The  $z_i$  vector contains variables related to personal demographic characteristics and individual farm-level attributes. It is also assumed that an individual will answer “yes” when their WTA is less than a certain bid value (i.e.,  $WTA_i < t^n$ ). Using these notions, we have the probability for the respondent answering “yes” to the first question and “no” to the second (one of the four possibilities) given by:

1.  $y_i^1 = 1$  and  $y_i^2 = 0$ .

$$\begin{aligned} Pr(y, n) &= Pr(t^2 < WTA \leq t^1) \\ &= Pr(t^2 < z_i'\beta + u_i \leq t^1) \\ &= Pr\left(\frac{t^2 - z_i'\beta}{\sigma} < \frac{u_i}{\sigma} \leq \frac{t^1 - z_i'\beta}{\sigma}\right) = \phi\left(\frac{t^2 - z_i'\beta}{\sigma}\right) - \phi\left(\frac{t^1 - z_i'\beta}{\sigma}\right), \end{aligned} \tag{2}$$

where the last expression follows from  $Pr(a < X < b) = F(b) - F(a)$ . Therefore, using symmetry of the normal distribution we have that:

$$Pr(y, n) = \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right) - \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right). \tag{3}$$

The two response combinations where the respondent answers “yes” or “no” to both dichotomous choice questions do not relate to a preexistent model. Therefore, a likelihood

function is constructed to directly estimate  $\beta$  and  $\sigma$  using maximum likelihood estimation (López-Feldman, 2012). The following likelihood function should be maximized to estimate the parameters for the model:

$$\sum_{i=1}^N \left[ d_i^{yn} \ln \left( \phi \left( z_i' \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right) - \phi \left( z_i' \frac{\beta}{\sigma} - \frac{t^1}{\sigma} \right) \right) + d_i^{yy} \ln \left( 1 - \phi \left( z_i' \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right) \right) \right. \\ \left. + d_i^{ny} \ln \left( \phi \left( z_i' \frac{\beta}{\sigma} - \frac{t^1}{\sigma} \right) - \phi \left( z_i' \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right) \right) + d_i^{nn} \ln \left( \phi \left( z_i' \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right) \right) \right] \quad (4)$$

Here,  $d_i^{yn}$ ,  $d_i^{yy}$ ,  $d_i^{ny}$ ,  $d_i^{nn}$  are indicator variables, each taking the value of either one or zero for each individual case, indicating that each individual contributes to the logarithm of the likelihood function in only one of the four parts (López-Feldman, 2012). This approach allows for direct estimation of  $\hat{\beta}$  and  $\hat{\sigma}$  unlike the single-bounded approach. The *doubleb* command in STATA was used to directly estimate the parameters and accurate WTA estimates with or without control variables can be obtained by incorporating the *nlcom* command.

## Results

In this research, we are interested in producer WTA values for adopting cover crops in their operations and the effects of producer demographics and farm characteristics on specific values. The personal demographic summary statistics of the overall sample are shown in Table 1. The average age of the surveyed respondents was 65.5 years old with over half (58%) of respondents being male. Whereas the 2022 Census of Agriculture reports the average age of U.S. producers as 58.1 years old and 36% female, our sample is older with a higher proportion of them being female (U.S. Department of Agriculture, 2024a).<sup>5</sup> Over 70% of the respondents have an education that extends past a high school degree, and the respondents derived 62.7% of their household income from agricultural production, on average.

Table 2 shows the summary statistics of the farm characteristics for the respondents. After agreeing to complete the survey, the first question provided to respondents asked them to state whether they own and/or operate land that produces agricultural commodities or whether they own land but lease it for agricultural production. Based on their response, they were then asked to complete the survey from the perspective of an agricultural producer or a non-operating landowner, respectively. The majority of the respondents (>83%) own or operate land that produces agricultural commodities (i.e., agricultural producer) while under 17% owned land but leased it for agricultural production (i.e., non-operating landowner), and the average total years of agricultural production experience among respondents was 52.58. Concerning recent operational decisions, only 34% and 33% of respondents had participated in an incentive program (e.g., EQIP or CSP) or planted cover crops in the previous 5 years, respectively. Respondents were also asked about the use of cover crops by other producers in the area surrounding their operation. On average, the respondents reported that 27.38% of the operations in their proximity had already adopted the use of cover crops. Also, 33% of the respondents did have irrigated acreage on their operation and the average total number of crops grown on each operation was 2.

### Willingness to accept

Table 3 illustrates the distribution of bid amounts presented to respondents. The three values of Bid 1, or  $t^1$  from equation 2, represent the first bid value respondents were presented in each of the three survey versions. Bid 2 values, or  $t^2$  from equation 2, were dependent upon responses to the previous bid and were 50% greater and 50% less than Bid 1 when the respondent answered “No” and “Yes,” respectively. In the first version of the survey, for example, respondents were first asked

<sup>5</sup>The 2022 Census of Agriculture reports the average age and percentage of female producers as 59.9 years old and 39% female in Texas and 57.7 years old and 40% female in Oklahoma, respectively (U.S. Department of Agriculture, 2024a).

**Table 1.** Summary statistics of demographic variables

Parameter	Description	Percentage of Occurrence	Mean	Std. Dev.
Age	Age of Respondent		65.500	12.753
	1 = 31–50	10.71%		
	2 = 51–70	53.58%		
	3 = $\geq$ 71	35.71%		
Gender	Dummy Variable		0.583	0.496
	0 = Female	41.67%		
	1 = Male	58.33%		
College	College Education		0.702	0.460
	0 = No	29.76%		
	1 = Yes	70.24%		
Production Income	% of Household Income from Agricultural Production		62.700	28.883
	0 = 0	5.95%		
	1 = 1–20	30.95%		
	2 = 21–40	8.34%		
	3 = 41–60	16.67%		
	4 = 61–80	11.90%		
	5 = 81–100	26.19%		

if they would accept \$10 per acre to implement a cover crop into their operation. If the respondent answered “No” to a first bid of \$10 per acre, their second bid increased by 50%–\$15 per acre. If they answered “Yes” to a first bid of \$10 per acre, their second bid decreased by 50%–\$5 per acre.

The individual responses to the combinations of bid vectors are presented in Table 4. When employing contingent valuation methods, it is important for survey respondents to be receptive to varying bid amounts. In willingness to pay studies, respondents are asked how much money they would give up from their limited budget constraints to purchase a product or service. Therefore, the percentage of “Yes” responses is expected to decrease as the bid values increase. However, the current WTA study asks respondents how much they would have to be compensated (i.e., increase their budget constraint) to adopt a specific practice in their operations. In line with neoclassical economic theory, that suggests individuals seek to maximize their utility or well-being subject to their budget constraints, we expect the percentage of “Yes” responses to increase as bid values increase. This assumption arises from the notion that as producers are compensated with increasing bid amounts, it becomes more favorable to adopt a specific practice in their operations, aligning with the rational decision-making framework central to neoclassical economics.

Results from Table 4 show how respondents were willing to engage with varying bid amounts. In Survey Versions 1 and 2 the percentage of “No” responses to the first bid far outweighs the percentage of “Yes” responses which shows the hesitancy among producers of adopting a new practice at lower bid values. The percentage of “No” responses is still greater for those who responded “No” to the first bid and were presented with a 50% higher second bid amount. This reluctance suggests that producers did not observe the compensation as enough to offset the perceived real costs, opportunity costs, or difficulties of adopting the practice. Survey Version 3,

**Table 2.** Summary statistics of farm characteristics

Parameter	Description	Percentage of Occurrence	Mean	Std. Dev.
Agricultural Producer	Land Ownership Status		0.833	0.375
	0 = Own but Lease (Nonoperating Landowner)	16.67%		
	1 = Own and/or Operate (Producer)	83.33%		
Production Years	Total Years in Agricultural Production		52.580	24.065
	1 = 0–10	9.52%		
	2 = 11–25	15.48%		
	3 = 26–40	17.86%		
	4 = 41–60	34.52%		
	5 = ≥ 61	16.67%		
	0 = None -- I Lease my Property for Ag. Production	5.95%		
Incentive Program	Participated in Incentive Program in the last 5 Years		0.345	0.478
	0 = No	65.48%		
	1 = Yes	34.52%		
Cover Crop Use	Planted Cover Crops in the Last 5 Years		0.429	0.498
	0 = No	57.14%		
	1 = Yes	42.86%		
Irrigated Acreage	Any Irrigated Acreage		0.333	0.474
	0 = No	66.67%		
	1 = Yes	33.33%		
% Already Adopted	% of Operations in Respondents' Area Already Using Cover Crops		23.095	22.813
	0 = 0%	14.29%		
	1 = 1–20%	46.43%		
	2 = 21–40%	16.67%		
	3 = 41–60%	15.58%		
	4 = 61–80%	3.57%		
Crop Diversity	Total Number of Crops Grown in the Operation		2.083	1.122
	1	40.48%		
	2	27.38%		
	3	16.67%		
	4	14.29%		
	5	1.19%		



**Table 3.** Distribution of CV Bid values

Survey Version	Bid 1	Bid 2	Frequency	Percent	Cumulative
<b>1</b>	10	5	10	9%	9%
		15	30	27%	35%
<b>2</b>	20	10	11	10%	45%
		30	26	23%	68%
<b>3</b>	30	15	18	16%	84%
		45	18	16%	100%

**Table 4.** Responses to each CV bid value

	Survey Version 1		Survey Version 2		Survey Version 3	
	<b>Bid 1</b>					
<b>Answer 1</b>	<b>10</b>		<b>20</b>		<b>30</b>	
<b>%No</b>	75		70		50	
<b>%Yes</b>	25		30		50	
	<b>Bid 2</b>					
<b>Answer 2</b>	<b>5</b>	<b>15</b>	<b>10</b>	<b>30</b>	<b>15</b>	<b>45</b>
<b>%No</b>	18	60	8	43	17	19
<b>%Yes</b>	7	15	22	27	33	31

which had the highest initial bid value, saw an equal proportion of “Yes” and “No” responses to the first bid value that potentially suggests closer alignment between the offered value and perceived costs and benefits. Also, a higher percentage of “Yes” responses were observed for the second bid values compared to the first and second versions of the survey. These results show useful insights into how responses progressed in relation to increasing or decreasing bid values showing the interaction between compensation and willingness to adopt the specific practice.

The results of the double-bounded WTA model for the entire sample (i.e., both producers and non-operating landowners) are presented in Table 5.<sup>6</sup> It is important to note that negative coefficients increase WTA while positive values decrease WTA. That is, negative values increase the amount that respondents would have to be paid on a per acre basis to adopt cover crops into their operation. Following Equation 1, mean values of each control variable were used to calculate an overall average WTA value of \$26.07/acre with lower and upper bounds of \$20.39 and \$31.75, respectively. Among the variables expected to influence WTA values, the only negative and statistically significant effects (i.e., values that increase WTA) come from the presence of irrigated acreage and operational status at the 1% and 10% levels, respectively. The largest influence is from the presence of any irrigated acreage where respondents would have to be paid \$17.26/acre more to adopt cover crops. Additionally, agricultural producers would require an additional \$11.18/acre to adopt cover crops as compared to non-operating landowners. This result is consistent with the fact that non-operating landowners would generally not bear the additional costs of adopting cover crops and, instead, the cost would be the responsibility of those possibly leasing the land.

<sup>6</sup>A Shapiro and Wilk (1965) test was conducted to confirm the normality of the residuals in Equation 1. The results of the test failed to reject the null hypothesis of normality, suggesting the residuals are approximately normally distributed.

**Table 5.** WTA estimates for cover crop adoption: producers and non-operating landowners

Parameter	Coefficient	Standard Error	<i>P</i> > <i>z</i>
Constant	-57.473***	12.060	0.000
Age	0.752	3.384	0.824
Gender	6.203	4.152	0.135
Education	8.089*	4.712	0.086
Production Income	1.737	1.436	0.226
Years in Production	2.618	1.703	0.124
Incentive Program	7.624*	4.591	0.097
Cover Crop Use	11.910**	4.852	0.014
Irrigated Acreage	-17.259***	5.758	0.003
% Already Adopted	4.773**	2.060	0.020
Crop Diversity	3.790	2.350	0.107
Agricultural Producer	-11.183*	5.920	0.059
Log-likelihood	-94.604		

Note: \*, \*\*, \*\*\* indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Regarding prior operational decisions, *Cover Crop Use* and *Incentive Program* are positive and statistically significant at the 5% and 10% levels, respectively. If respondents had implemented cover crops in their operation or participated in an incentive program in the last five years their WTA decreases by \$11.91/acre and \$7.62/acre, respectively. Moreover, respondents are also influenced by surrounding operations in their area as *% Already Adopted* is positive and statistically significant. The higher the percentage of surrounding operations that have already adopted cover crops, the less respondents would be willing to accept to adopt the practice themselves. Also, if respondents have a college education (*Education* = 1) their WTA decreases by \$8.09/acre. While *Crop Diversity* is not statistically significant, our findings show that willingness to accept decreases with more diversity of crops grown which is consistent with previous literature indicating that more crop diversity is a positive indicator of adoption (Arbuckle & Roesch-McNally, 2015; Lu *et al.*, 2022; Singer *et al.*, 2007).

Given our sample in Table 5 includes both active producers and non-operating landowners, the results indicate the overall impact of prior decisions across both of these groups. For active producers, the effect is likely a result of the direct experience of managing land for agricultural production, while for non-operating landowners, the effect could indicate a general awareness of the practices adopted by their tenants. Furthermore, non-operating landowners could possess a general familiarity with the benefits associated with cover crop adoption or have prior experience that influences their willingness to accept values. As Sawadgo *et al.* (2021) found that non-operating landowners have different perspectives on cover crop adoption from owner-operators, we test the robustness of our results by eliminating non-operating landowners from the analysis. Table 6 shows the results of the double-bounded WTA model after the removal of non-operating landowners. The overall average WTA for producers only is \$26.38/acre which is slightly greater than when non-operating landowners are included in the model. For context, this average value reflects approximately 78% of the estimated cost from the EQIP to implement a basic cover crop in the state of Texas for the 2022 fiscal year. Assuming a 50-75% cost-share payment, the respondents would, on average, still require additional financial incentive to implement cover cropping in their operations.

**Table 6.** WTA estimates for cover crop adoption: producers only

Parameter	Coefficient	Standard Error	<i>P</i> > <i>z</i>
Constant	-76.786***	13.274	0.000
Age	-0.094	3.792	0.980
Gender	7.810*	4.447	0.079
Education	10.230**	5.102	0.045
Production Income	1.809	1.528	0.236
Years in Production	5.447**	2.137	0.011
Incentive Program	7.092	4.625	0.125
Cover Crop Use	11.382**	5.118	0.026
Irrigated Acreage	-18.980***	6.608	0.004
% Already Adopted	4.332**	2.161	0.045
Crop Diversity	3.800	2.586	0.142
Agricultural Producer	-	-	-
Log-likelihood	-76.950		

Note: \*, \*\*, \*\*\* indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Additionally, *Years in Production* is statistically significant at the 10% level and shows that producers who have been engaged in agricultural production for a longer period of time would be willing to accept less to adopt cover cropping. This result may reflect the fact that producers with more experience have a greater sense of devotion to their operations and could be inclined to adopt conservation practices out of a sense of responsibility toward land stewardship (Chouinard et al., 2016). *Education*, *Cover Crop Use*, *Irrigated Acreage*, and *% Already Adopted* remain both statistically significant and similar in magnitude to the results when non-operating landowners are included in the analysis. However, previous enrollment in an incentive program no longer has a statistically significant impact on WTA and *Gender* is statistically significant at the 10% level. Male producers would be willing to accept a lower amount per acre to adopt cover crops compared to female producers. This finding is consistent with previous research indicating that while female farmers are generally more conservation-minded, they have less experience with government conservation programs and are less knowledgeable about best management practices compared to their male counterparts (Druschke & Secchi, 2014; Wells & Eells, 2011).

## Discussion and conclusion

The agricultural sector increasingly recognizes the role of regenerative practices in mitigating the effects of climate change, sustaining production, and preserving natural resources. However, despite attempts to promote such practices and increasing awareness, the widespread adoption of regenerative agricultural practices remains a significant challenge. Using a double-bounded contingent valuation framework, we evaluate WTA values of producers in the SGP to adopt cover cropping into their operations and how various personal demographics and farm characteristics affect WTA.

Our findings indicate an average WTA value of \$26.38/acre for producers with many factors having considerable impacts on WTA values. Notably, this average value is greater than 75% of the 2022 EQIP estimated cost of implementing basic cover crops in Texas. This indicates the net private cost to producers could be substantial even after accounting for cost-share support

payments, potentially limiting their willingness to adopt the practice. Addressing the gap between what producers indicate they are willing to accept, and the actual costs of implementation may be essential to increasing adoption rates. Several demographic factors and farm characteristic variables were found to have an influence on WTA values. For instance, producers with a college education were willing to accept over \$10/acre less to adopt cover crops compared to those without. WTA values also decreased with higher percentages of neighboring properties having adopted the practice and with increasing crop diversity. This finding is in line with Liu *et al.* (2018) who found that adoption by neighbor(s) positively impacts the adoption of best management practices by farmers. Though not statistically significant, we also found crop diversity to negatively impact WTA where producers growing a more diverse array of commodities were willing to accept lower incentive payments to adopt cover crops. Because crop diversity can be associated with integrated crop-livestock systems, these producers may have additional paths for revenue to offset costs associated with cover crop adoption, more compatible operations for integration, or observe direct benefits from adopting cover crops (e.g., grazing for livestock) (Arbuckle & Roesch-McNally, 2015).

Conversely, the presence of irrigated acreage and ownership status were among the factors having the largest impact on WTA, and the only two that actually increased required incentive payments for producers. That is, producers who have irrigated land require more financial incentive to adopt cover cropping compared to dryland producers and those that lease out their land (i.e., non-operating landowner). This shows how agricultural operations with specific arrangements may require additional compensation to adopt cover crops. From a theoretical perspective, irrigated acreage involves additional input costs (e.g., additional water for cover crops, energy, and labor) and opportunity costs from diverting irrigation resources to cover crops and away from cash crops with higher immediate returns. Moreover, producers may perceive a level of uncertainty regarding the expected benefits of cover crops, especially when additional financial investments may be needed for irrigation. These considerations could necessitate higher incentives for producers with irrigated acreage to offset these risks and ensure the marginal benefit of adoption outweighs the marginal cost, and understanding these economic barriers is crucial for designing effective policy interventions.

We found that incentive payments for producers who have previously utilized cover crops or been enrolled in an incentive program are lower compared to those who have done neither. This is consistent with Canales *et al.* (2024) who found lower incentive payments are required for producers who have previously adopted conservation practices. Whereas Canales *et al.* (2024) include various regenerative practices in their analysis, our findings show that continuity of utilizing cover crops specifically has a lower cost compared to additionality. While incentivizing current adopters to continue use may be a more cost-effective strategy, the broader goal of increasing adoption rates requires attracting new adopters. Therefore, programs and strategies aimed at targeting new adoption rather than continuity may require more substantial investments as new adopters are less aware of perceived risks, benefits, and costs associated with adoption.

These findings have important implications for both policy and extension efforts aimed at the promotion of regenerative agricultural practices. Specifically, understanding the differential WTA values can inform the design of incentive programs and target producers who require greater financial compensation for adoption. The effectiveness of federal, state, and local programs can be enhanced by tailoring incentives to meet the requirements of specific producer groups. Additionally, our research highlights the importance of knowledge dissemination and practical experience in increasing rates of adoption. Familiarity with incentive programs and cover cropping both lowered WTA values which shows that direct experience and exposure to regenerative practices are significant factors in reducing perceived barriers to adoption. As a result, increased investment in educational and extension programs, field demonstration plots, and peer learning networks can encourage adoption among hesitant producers by increasing involvement and knowledge of both regenerative practices and incentive programs. The findings

also show the importance of tailoring conservation program efforts to the specific circumstances and needs of various producer groups.

In addressing the remaining barriers to adoption of regenerative agricultural practices, our study highlights the need for continued research and innovation in the agricultural economy. Although incentive programs may play a significant role in the adoption of regenerative practices, they may fail to capture the diverse range of both costs and benefits associated with the adoption of cover crops. Future research may aim to look at alternative mechanisms such as cost-sharing schemes, insurance premium reduction, novel financial models, etc. to ensure the long-term sustainability of regenerative agriculture and to further incentivize adoption. While our results showed that higher rates of cover crop adoption by neighboring operators decreases WTA, future research should aim to see whether factors beyond direct influence from neighbors' impact adoption.<sup>7</sup> Furthermore, we found WTA values to be less for male producers compared to female producers. Female producers want and are willing to learn more about best management practices, and increased adoption of these practices may be attained if government conservation programs tailor educational information and increase outreach to female producers (Druschke & Secchi, 2014).

Finally, a few limitations of the study should be noted. First, the study had a limited sample size with only 84 responses being incorporated into the WTA analysis. Though a lower response rate is common with mail surveys compared to online surveys, future research may aim to choose a survey format more accessible to agricultural producers. Also, our sample is contained within a specific, semi-arid geographic region (i.e., Texas and Oklahoma). Similar outcomes may be found in other semi-arid ecosystems, but future work should aim at obtaining a broader sample from various ecosystem types to obtain more generalizable results regarding the adoption of regenerative agricultural practices.

**Supplementary material.** The supplementary material for this article can be found at <https://doi.org/10.1017/aae.2024.30>.

**Data availability statement.** For replication purposes, the data that support the findings of this study are available from the corresponding author, T.D.J, upon reasonable request.

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<sup>7</sup>As pointed out by a reviewer, farmers may engage in independent intelligence gathering, regional benefits may create localized trends of adoption, and the social structure in a region may facilitate the spread of regenerative practices.

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