Forest Policy and Economics 92 (2018) 43–54

Contents lists available at ScienceDirect

Forest Policy and Economics

journal homepage: www.elsevier.com/locate/forpol

Cattle producer willingness to afforest pastureland and sequester carbon

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ARTICLE INFO

Keywords:
Willingness-to-afforest
Carbon sequestration
Pasture
Triple-hurdle regression

JEL classification:
Q15
Q23
Q24

ABSTRACT

The beef industry can mitigate climate change by reducing greenhouse gas emissions associated with cattle production and increasing carbon sequestration on grazing lands. One alternative for increasing carbon sequestration is to convert pasture to forest while either reducing animal numbers or increasing cattle stocking density on more productive pastureland. This study uses data from a survey of beef cattle producers in the eastern United States to determine: (i) interest in afforesting pastureland; (ii) contingent upon interest, willingness to participate in a hypothetical afforestation program; and (iii) contingent upon willingness to participate, participation intensity in the form of enrolled acres. Less than one-third of producers were interested in afforesting pasture. Producer interest was associated with beliefs about the on- and off-farm effects of afforestation, risk aversion, age, educational attainment, opportunity costs, forest ownership, and previous experience with afforestation. Willingness to participate in the program was influenced by the incentive offered, household income, and opportunity costs. Respondents willing to participate in the program were willing to afforest an average of 55 acres, given the incentive offered. Producers with larger farms were willing to enroll more acres. Extrapolating these results to the population of beef cattle producers in the eastern United States provides a measure of the potential for pasture afforestation and carbon sequestration.

1. Introduction

Enteric fermentation and manure management attributable to livestock production account for over 42% of the greenhouse gas (GHG) emissions from agriculture in the United States (US) and about 3.5% of all US GHG emissions (USEPA, 2016). Changes in livestock production practices could lead to substantial reductions in GHG emissions (Cottle et al., 2011; Gerber et al., 2013; Hristov et al., 2013a,b; Luo et al., 2010; Montes et al., 2013). Accumulation of atmospheric GHGs could also be decreased by increasing carbon sequestration on some of the US's 614 million acres (248 million hectares) of grassland pasture and rangeland (Nickerson et al., 2011). One approach would be to afforest some of this land (Follett et al., 2001; Lee and Dodson, 1996) while either decreasing cattle numbers or increasing cattle stocking density through practices such as management intensive grazing (Gillespie et al., 2007; Jensen et al., 2015). Afforestation of pasture has been identified as a relatively cost-effective GHG mitigation strategy (Feng et al., 2006; Lubowski et al., 2006; Moulton and Richards, 1990; Parks and Hardie, 1995; Richards and Stokes, 2004; van Kooten et al., 2004).

This study informs the design and implementation of voluntary policies to increase carbon sequestration in the US by enhancing understanding of agricultural producer attitudes toward afforestation and participation in a hypothetical voluntary program encouraging afforestation. Specifically, the willingness of cattle producers east of the 100th meridian to convert pasture to forest and how this willingness varies across livestock producers and operations is estimated using a survey of beef cattle producers. The survey was limited to livestock operations in the eastern US because of concerns over the difficulties of afforestation in the Great Plains and more arid West.

The notion of afforesting farmland to sequester carbon may be relatively recent, but programs to incentivize farmland afforestation have existed for decades (Mather, 1998). However, participation rates in these programs have often failed to match expectations (Duesberg et al., 2014a,b). Surveys of farmers suggest that producer objections to the afforestation of productive farmland may help explain lower-than-anticipated participation rates (e.g., Kassioumis et al., 2004; Frawley, 1998; Clark and Johnson, 1993; Ní Dhubháin and Gardiner, 1994; Ní Dhubháin and Wall, 1999; Gasson and Potter, 1988; Schirmer and Bull, 2011). Previous studies have investigated producer willingness to afforest agricultural land to promote carbon sequestration. van Kooten et al. (2002) and Shaikh et al. (2007) surveyed landowners in Western Canada, while Kim and Langpap (2016) surveyed landowners in western Oregon and Washington. The survey instrument used in the latter study presented respondents with a hypothetical incentive program

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https://doi.org/10.1016/j.forpol.2018.03.004
Received 24 December 2017; Received in revised form 7 March 2018; Accepted 19 March 2018
Available online 24 April 2018

similar to the one used in this study.[1] Forty-eight percent of the Kim and Langpap (2016) respondents were unwilling to afforest agricultural land even if the "right" conditions and incentives were offered. Thus, one hypothesis of this study is that a sizable share of respondents will be uninterested in afforesting pasture and unwilling to enroll in an afforestation program. However, a survey of Australian landowners found that 80% were at least interested in afforesting to affect carbon sequestration (Schirmer and Bull, 2011), suggesting that producer attitudes toward afforestation might vary by region and over time.

2. Survey data

Data were collected with a mail survey of beef cattle operations with at least 20 head of cattle in the eight US Department of Agriculture-Economic Research Service (USDA-ERS) production regions east of the 100th meridian (i.e., Heartland, Northern Crescent, Northern Great Plains, Prairie Gateway, Eastern Uplands, Southern Seaboard, Fruitful Rim, and Mississippi Portal) (USDA-ERS, 2000).[2] A stratified random sample of 8875 operations was drawn by the USDA's National Agricultural Statistics Service (NASS) from the population of 267,413 farms. Survey strata were based on ERS production regions and farm sales classes (i.e., < $10,000; $10,000–$29,999; $30,000–$49,999; $50,000–$99,999; $100,000–$149,999; $150,000–$199,999; $200,000–$499,999; > $500,000). Sampling intensity was based on a 3% margin of error with a 95% confidence interval. Post-stratification weights were generated based on a cross tabulation of farm sales classes and ERS regions (Lambert et al., 2014). USDA/NASS fielded the survey in 2013 with an initial mailing, a reminder postcard (one week after the first mailing), and a second follow-up mailing (two weeks after the reminder). A total of 2448 completed surveys were returned for a 28% response rate. After eliminating observations with missing entries, there were 1026 surveys were available for this analysis. Expanding the sample by the survey weights results in a projected 112,445 farms.

The survey instrument consisted of three sections. The first section included questions on farm characteristics. Section two provided respondents information on afforestation and how it could benefit their operation and the environment (Fig. 1), along with regionalized estimates of establishment and maintenance costs (Fig. 2). Three questions on respondent willingness to afforest and participate in a hypothetical afforestation incentive program followed (Fig. 3). The first question asked about respondent willingness to afforest pastureland and provided respondents with three response options: not willing even if afforestation was profitable, willing to afforest only if it was profitable, and willing to afforest even if it was unprofitable. Respondents unwilling to afforest even if profitable ("Non-adopters") were asked to skip the other questions in the choice experiment. Respondents who indicated they were either willing to afforest if profitable or willing to afforest even if not profitable ("Adopters") were asked if they would, hypothetically, participate in a program that would pay them 75% of the costs of afforesting pastureland in addition to an annual payment for ten years for each acre of pastureland afforested (Fig. 1). While this question did not explicitly reference any program conditions beyond the ten-year payment period, the survey's description of afforestation and voluntary afforestation incentive programs states that "these programs allow trees to be sustainably harvested at the end of the program period," but "may prohibit the forest product that is harvested from being burned or turned into fuel" (Fig. 1). The amount of the annual per acre payment – which was informed by a pretest of the survey instrument with 300 producers – varied randomly across surveys between $60, $90, $120, $150, and $180 per acre ($148.26, $222.39, $296.53, $370.66, and $444.79 per hectare). Respondents willing to participate in the hypothetical program, given the incentive offered, were then asked how many acres they would afforest. The last set of questions in this section of the survey asked respondents about the factors influencing their responses to the choice experiment questions and their perceptions of the on-farm impacts associated with pastureland afforestation. The final section of the questionnaire included attitudinal questions and questions pertaining to respondent characteristics.

One way to assess the representativeness of the sample used in this analysis is to compare average values of farm or farmer characteristics to average values from the 2012 Agricultural Census for those states either wholly or partly east of the 100th Meridian. However, the value of this comparison is somewhat limited by the fact that our sample is of beef cattle operations with at least 20 head of cattle as opposed to all farms in this region. Given this qualification, the average farm size for our sample (267 acres) is smaller than that reported in the Census (357), while our respondents are, on average older (62 to 58 years) and less likely to work off-farm (52 to 61%) than all principal operators in the region. Possible explanations for these differences include the difference in populations (beef cattle producers as opposed to all farmers) and non-response bias.

3. Economic model

The skip pattern of the survey is accommodated by a tiered modeling approach (Jensen et al., 2015; Qualls et al., 2012) that extends Heckman's (1976) sample selection model. The triple hurdle regression model encompasses three levels of analysis: (1) willingness to afforest pastureland; (2) willingness to commit to the hypothetical incentive program, given willingness to afforest and the per acre incentive offered; and (3) participation intensity, gauged by the number of acres the respondent would be willing to enroll into the hypothetical program, given willingness to commit to the program and accept the incentive. The three-tiered hurdle model allows the factors influencing responses to vary across the three decision tiers.

In the absence of an incentive, afforestation is hypothesized to occur when the producer's utility (u) from afforesting pasture (A) is at least as great as the producer's utility without afforesting. In other words, producer i afforests when $u_1(1, I_i; X_i) + e_{i1} \geq u_1(0, I_i; X_i) + e_{i0}$, where 1 denotes afforestation of pastureland, 0 otherwise; I is income; X is a vector of operator characteristics and farm attributes affecting the decision to afforest; and e is a stochastic unobserved component of utility. Utility is a random variable, and the likelihood of a producer expressing interest in a program can be extended to a probabilistic framework (Shaikh et al., 2007). For example,

$$\begin{aligned} Pr(AFFOREST_i = 1 \mid X_i) &= Pr(u_1(1, I_i; X_i) \\ &\quad + e_{i1} > u_1(0, I_i; X_i) + e_{i0}) \\ &= Pr(X_i\theta_1 + e_{i1} > X_i\theta_0 + e_{i0}) \\ &= Pr(X_i(\theta_1 - \theta_0) + e_{i1} - e_{i0} > 0) \\ &= Pr(\varepsilon_{1i} > -X_i\beta_1) \end{aligned} \quad (1)$$

Assuming the stochastic component is normally distributed with an expected value of zero and variance of one,

$$Pr(AFFOREST = 1) = \Phi(X_i\beta_1) \quad (2)$$

where Φ is the standard normal cumulative distribution function.

Along these lines, the first tier of the model distinguishes respondents interested in and potentially willing to afforest (*AFFOREST*) from those unwilling to afforest even if the practice is profitable as a latent variable:

[1] The primary differences in the hypothetical programs are that Kim and Langpap (2016) offered respondents a 50% cost share and annual payments for 15 or 30 years for afforesting either cropland or grassland, while the hypothetical program in this study offered respondents a 75% cost share and annual payments for 10 years for afforesting pasture.

[2] The 100th meridian roughly divides the continental US in half – running from Texas through the Dakotas – and is a commonly used line of demarcation between the eastern and more arid western US.