

Are Ranchers Interested in Joining the Carbon Market? Survey Says: Maybe



By Nicole Nimlos, Christopher Bastian, and John Derek Scasta

Nicole Nimlos is a Ph.D. student in the Department of Ecosystem Science and Management in the College of Agriculture, Life Sciences, and Natural Resources (CALSNR) at the University of Wyoming; contact her at nnimlos@uwyo.edu. Christopher Bastian is a professor in the Department of Agricultural and Applied Economics in CALSNR at the University of Wyoming. John Derek Scasta is an associate professor in the Department of Ecosystem Science and Management in CALSNR and the director of the Laramie Research and Extension Center at the University of Wyoming.

Abstract

The carbon market offers an opportunity for ranchers to receive compensation for engaging in stewardship practices that sequester greenhouse gases. We present results from a survey administered in January 2024 of 504 ranchers across 10 Great Plains and Front Range states exploring their willingness to join the carbon market, and their reasons for non-participation. We found that 55% of respondents are interested in joining a grassland carbon market program. Top non-participation reasons include concerns about long-term contracts, payment amounts, and having a

conservation easement to be eligible. Private carbon markets and future federal programs should consider ranchers' preferences for enrollment if they want to encourage participation.

INTRODUCTION

The voluntary carbon market (hereafter “carbon market”) presents an emerging opportunity for producers to generate an additional stream of income while practicing land stewardship. Despite the potential for carbon sequestration on grazing lands (i.e., rangelands and grasslands suitable predominantly for livestock grazing, hereafter “grasslands”; Stanley et al., 2024), recent research primarily has focused on crop producer preferences related to this emerging market (Derner and Schuman, 2007; Kalady et al., 2024). Since the collapse of the Chicago Climate Exchange (CCX) in 2011, the carbon market has evolved to include a wider range of carbon companies and programs available for ranchers as well as farmers. To participate in the carbon market, ranchers must improve their land management practices to sequester additional carbon dioxide (CO₂) from the atmosphere. Such practices include rotational grazing, reseeding, applying fertilizer, or enrolling in a conservation easement, all of which typically results in optimizing plant growth and consequently affecting carbon sequestration (Jordon et al., 2022; Leghari et al., 2016). The CO₂ captured in the soil because of these improved practices can then be sold as carbon credits (hereafter “credits”). One credit is equal to the sequestration of one metric ton of CO₂ equivalents in soil or the prevention of one metric ton of CO₂ from being released. The average price of a carbon credit in the agricultural sector sold for \$6.43/credit in 2023 (Ecosystem Marketplace, 2023), though prices are influenced by market supply and demand. These credits can be purchased by individuals and companies to offset the emissions produced from their activities. There are 170 different types of credits (e.g., those related to forestry, methane capture, waste management, etc.) that can be generated (Ecosystem Marketplace, 2022). Our research focuses

specifically on credits derived from ranchers' livestock management practices on grasslands.

We present survey data exploring ranchers' willingness to participate in the carbon market who are located in the 10 states in the Great Plains and Front Range of the United States. This research is the first to explore ranchers' preferences for contemporary carbon programs that involve livestock management on such lands used for grazing.

BACKGROUND

Ranchers can work with numerous carbon companies (referred to as "project developers") to develop a carbon project on the property they own or manage. Carbon company programs vary in contract length, payment amounts and frequencies, management change requirements, and enrollment rates, but they adhere to the fundamental rules established by the registries. These registries develop the methodologies or protocols that define the requirements that projects must meet to generate and sell credits (Brammer and Bennett, 2022). The three prominent registries with grassland protocols relevant to ranchers are American Carbon Registry (ACR), Climate Action Reserve (CAR), and Verra. Grassland protocols require carbon projects to either collect soil samples and measure soil carbon every five years or enroll the property into a conservation easement. Ranchers who participate in the carbon market sign a contract with a carbon company, committing to follow the contract's guidelines. The carbon company manages the project, maintains the necessary paperwork and records, and serves as the liaison with the registries (Brammer and Bennett, 2022). The carbon company typically covers the costs associated with developing the carbon project (i.e., market entry fees, infrastructure improvements, soil sampling, etc.) and assumes the financial risk by purchasing the rights to the credits. Ranchers can "shop around" between different carbon companies (e.g., Agoro, Ducks Unlimited, Grassroots, Kateri, Native) to select a program that best aligns with their goals (Nimlos, Gergen, and Scasta, 2025).

Previous research examines potential costs and profitability for grassland producers participating in carbon markets using CCX prices (Ritten, Bastian, and Rashford, 2012; Campbell et al., 2004), but literature examining ranchers' current preferences for carbon programs on grasslands is limited. However, research in the broader carbon market suggests that while crop farmers are generally aware of carbon markets and are interested in selling credits, they often face uncertainty regarding information, policies, and

associated costs (Han and Niles, 2023). Other research suggests that farmers have a low willingness to join the carbon market, with carbon program design and farmer characteristics contributing to the reluctance (Kolady et al. 2024). Crop carbon markets often require farmers to reduce tilling or plant cover crops, whereas grassland carbon markets typically involve improving grazing (i.e., increasing pasture rest periods). Thereby, willingness to engage in the carbon market may differ between row crop farmers and livestock ranchers, highlighting the importance of exploring ranchers' preferences separately from crop farmers. Lastly, research indicates producer and property characteristics (e.g., age, gender, property size, etc.) impact willingness to enter into forest carbon contracts, with younger, female respondents operating on larger sized properties being more willing (Sharma and Kreye, 2022; K.A. Miller, Snyder, and Kilgore, 2012).

Understanding ranchers' preferences for the carbon market informs critical design elements of both current programs in private markets and potential future government initiatives. In 2023, the United States Department of Agriculture (USDA) invested \$8 million to support and expand the measurement and monitoring of soil carbon on working agricultural lands to assess how climate-smart practices impact carbon sequestration.¹ This investment suggests that federally run voluntary carbon programs may emerge in the future. Thus, this research may offer valuable insights for tailoring such programs to better meet ranchers' needs while supporting agricultural production in the U.S.

METHODS

Survey Methods

We obtained our data for this research by administering a modified Dillman design survey using a hybrid delivery approach (mixture of online and paper mail survey delivery; Dillman, Smyth, and Christian, 2014). DTN services (www.dtn.com) provided a randomly selected list of eligible landowners or land managers that included their physical addresses and emails. We initially emailed participants to inform them that a survey would be arriving in the mail. We then mailed the survey to participants' physical addresses and sent two reminder emails at two-week intervals to encourage completion. Respondents also had the option to complete the survey online via *Qualtrics*. We received 504 valid surveys ($n = 504$) and 100 invalid surveys due to return to sender, deceased respondents, or respondents who had moved away. Given our initial sample size of 3,500 ranchers, our response rate was 15%.

We mailed our survey to 3,500 ranchers in January 2024, targeting ranchers who own or operate on 200 or more acres of grasslands, rangelands, or shrublands in 10 states within the Great Plains and Front Range, including Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming. We distributed an equal number of surveys to each state in attempt to ensure representative coverage of ranchers from our target population.

The survey first asked respondents to select all the enterprises they operated on their land, including cattle and calves, hay, hogs and pigs, sheep or goats, horses, ponies, mules, burros, or donkeys, poultry or eggs, non-hay crop production, or other (the survey is available upon request from the corresponding author). We also inquired about the state where the majority of their property was located, property size, gender, and age range (18-24, 25-44, 45-64, 65-84, or 85 or above). We proceeded to ask respondents to indicate whether they had heard of the carbon market prior to the survey (yes, no, somewhat).

Next, we provided respondents with the following preamble: "Imagine you have been contacted by a carbon project developer. They have presented you with an opportunity to participate in a grassland carbon project and have offered you a contract for three different programs that you could enroll in. Additionally, the project developer has successfully secured a buyer who is interested in purchasing the carbon credits generated by your participation in the program. This means that your management efforts will have a tangible value in the market. Below, you will find the characteristics of three different grassland carbon programs." We then presented respondents with three carbon programs that varied in their characteristics, including the requirement to enroll in a conservation easement, soil testing requirements, contract length, and an established record of the program selling carbon credits. These programs represented existing programs in the carbon market under American Carbon Registry's *Avoided Conversion of Grasslands and Shrublands to Crop Production* protocol, Climate Action Reserve's U.S. Grassland Protocol, and Verra's VM0026 *Methodology for Sustainable Grassland Management*.

We then asked respondents whether they would enroll in any of the three programs. We posed this question four times with varying payment amounts based on current market levels to gauge overall willingness to participate in any of the programs.

Finally, we asked respondents who were not interested in enrolling in one or all of the carbon programs to select the reasons for their reluctance. For institutional research compliance, this study was reviewed by the University of Wyoming Institutional Review Board (IRB) and determined to be exempt from further federal regulations on September 26, 2023.

Data Analysis

We generated a binary response variable for our initial analysis, coded as "1" if ranchers selected one of the three programs or "0" if they opted out in all four questions. We calculated the proportion of ranchers willing to join the carbon market and the Wald 95% confidence intervals for this proportion. We used chi-square tests of independence to examine relationships between respondents' age, awareness of the carbon market (yes or somewhat = 1, no = 0), gender (male = 1, female = 0), and location with their willingness to participate in the carbon market. Chi-square tests of independence are useful for determining whether two categorical variables in a sample are independent or associated with each other (Franke, Ho, and Christie, 2012). We ensured the chi-square tests met the assumptions of categorical and mutually exclusive variables, independent observations from a random sample, and expected cell counts of five or more in the contingency tables (Naioti and Mudrak, 2022). We calculated Adjusted Pearson residuals to identify which categories contributed significantly to the chi-square test, with residuals having absolute values greater than the critical value of 1.96 considered significant at the $\alpha = 0.05$ level (Naioti and Mudrak, 2022).

We conducted a multiple logistic regression to assess whether operation type, property size, or respondent location could predict willingness to join the carbon market, given past research regarding willingness to enter forest carbon contracts (Sharma and Kreye, 2022). We created binary variables for each operation type and coded them as "1" if respondents engaged in that enterprise or "0" if they did not. We treated privately owned and leased acres as continuous variables, then we set location as a factor variable, with 10 levels corresponding to respondents' states and New Mexico set as the reference level. We also examined potential issues of multicollinearity via variance inflation factors (VIFs; Shrestha, 2020). We utilized R software for all analyses and considered p-values less than 0.05 as statistically significant.

RESULTS

Demographics

Presented in order from greatest to least, we received 68 surveys from Wyoming (14.11%), 64 from Colorado (13.28%), 58 from Kansas (12.03%), 56 from Montana (11.62%), 54 from North Dakota (11.20%), 53 from Nebraska (11.00%), 49 from South Dakota (10.17%), 41 from Oklahoma (8.51%), 33 from Texas (6.85%), and 6 from New Mexico (1.24%; Table 1; Figure 1). Twenty-two respondents did not indicate their location. The largest share of respondents raised cattle and calves ($n = 431$, 89.42%), were male ($n = 402$; 83.75%), and between 65 and 84 years old ($n = 282$, 57.79%; Table 1). On average, respondents operated on 3,132 leased acres (median = 988; range = 20-100,000) and 2,297 deeded acres (median = 1,000; range = 6-28,000; Table 2). Our survey included over 720,000 leased acres and 957,000 deeded acres, encompassing over 1.6 million acres.

Willingness to Join the Carbon Market

The majority of respondents were aware, or somewhat aware, of the carbon market prior to the survey ($n = 286$; 57.78%; Table 3). Fifty-five percent of respondents indicated they would participate in one of the presented carbon programs ($n = 262$; 54.93%) rather than opting out of all of them ($n = 215$; 45.07%; Table 4). Statistically, the proportion of ranchers interested in joining the market falls between 50% and 59% (95% Confidence Interval). It should be noted that we cannot assess whether respondents' stated intentions may differ from their actual behavior if given the opportunity to participate in the carbon market. Colorado ($n = 41$), Wyoming ($n = 33$), and Kansas ($n = 30$) had the most respondents select a carbon program (Figure 2). The states with the largest proportion of respondents willing to participate in the market were Colorado (66%), Texas (58%), Nebraska (57%), and North Dakota (57%; Figure 3).

Barriers to Enrollment

Respondents who opted out of one or all of the presented programs indicated that they did not want to enter into a long-term contractual agreement ($n = 217$; 43.06%), the financial compensation was not high enough ($n = 189$; 37.50%), they did not want to enroll their land in a conservation easement ($n = 138$; 27.38%), they do not trust the carbon market ($n = 118$; 23.41%), they do not want to sell carbon credits to polluting companies ($n = 82$; 16.27%), they do not want to change their management practices ($n = 59$; 11.71%), another reason ($n = 47$; 9.33%), or the costs to join the market are too high ($n = 39$; 7.74%; Table 5; Figure 4).

There was a significant relationship between willingness to join the market and age, but not with awareness of the market, gender, or location (Table S1 in the supplementary section). Given that 84% of respondents were male, it is not surprising that there was no significant relationship between willingness to participate and gender. These results might differ if the survey had a higher proportion of female respondents, as research suggests that women are generally more willing to engage in pro-environmental behaviors (Casaló and Escario, 2018; Casaló, Escario, and Rodriguez-Sanchez, 2019; Briscoe et al., 2019). Ranchers around 55 years old were more likely to enroll in a carbon program than those around 75 years old (Table S2 in the supplementary section). Survey responses were low among respondents aged 18-24 (0%), 25-44 (5%), and 85 or older (5%), so it is not surprising that no significant relationship was observed from those age ranges. Our regression results indicate respondents with haying operations and more privately owned acres were more likely to enroll in a carbon program, while those conducting non-hay crop production were less likely (Table S3 in the supplementary section).

It is important to note that females and ranchers in New Mexico were underrepresented in this survey. While females make up 36% of producers in the U.S. (USDA, 2022), only 16% of our survey respondents were female. Additionally, only 1.24% of respondents were located in New Mexico. Thus, conclusions about females and ranchers in New Mexico are limited. Additionally, the mean age of survey respondents was 66 years, which is slightly higher than the average age of 58 years for producers in the U.S. (USDA, 2022). Future research efforts should include a larger and more diverse sample of ranchers from a broader range of states.

DISCUSSION AND CONCLUSION

We've presented a first look at survey data assessing ranchers' willingness to participate in the carbon market and explored reasons why some ranchers are hesitant. Our results reveal that 55% of respondents were interested in joining the carbon market. This willingness is higher compared to findings from studies on crop and forest producers' willingness to participate in the carbon market (Canales, Bergtold, and Williams, 2023; Markowski-Lindsay et al., 2011; K.A. Miller, Snyder, and Kilgore, 2012). Our results also indicate that younger ranchers are more likely to enroll in the carbon market compared to older ranchers, a trend observed in studies on landowners' willingness to join conservation programs (Farmer et al., 2017;

Langpap, 2004). Additionally, ranchers with larger properties were more willing to participate in the carbon market, a finding also consistent with other research on landowners' willingness to join the carbon market (Dickinson et al., 2012; K.A. Miller, Snyder, and Kilgore 2012). This result is understandable because larger property sizes often offer greater revenues from the carbon market, so landowners with smaller properties may consider aggregating with neighboring landowners to enhance the project's appeal (Kerchner and Keeton, 2015).

Interestingly, we found that ranchers who hayed were more likely to participate in the carbon market, which is a new finding in the literature. This is notable because some carbon programs incentivize ranchers to apply nitrogen fertilizer and reseed, practices that may align well with haying. On the contrary, ranchers who also conducted non-hay production were less willing to join the market, which is consistent with other literature stating farmers have low willingness to participate in carbon markets (Canales, Bergtold, and Williams, 2023). A portion of respondents had never heard of the carbon market before this survey, suggesting that educating ranchers about the opportunities available to them within the carbon market will be necessary. Informing ranchers about the additional ecological and societal benefits of improving management through a carbon program could also be important for promoting the adoption of conservation practices (Canales, Bergtold, and Williams, 2023).

Respondents who chose to opt out of one or all programs noted concerns about long contract lengths, low payments, and requirements for enrolling in a conservation easement. These concerns are consistent with findings from existing literature that identify long contracts and low payments as significant barriers to crop and forest landowners enrolling in the carbon market (Markowski-Lindsay et al., 2011; Sharma and Kreye, 2022; K.A. Miller, Snyder, and Kilgore, 2012). The current compensation offered to landowners for participating in the carbon market is likely insufficient, both in terms of encouraging widespread enrollment and in the benefits being provided to society (e.g., the provision of ecosystem services, wildlife habitat, open spaces, etc.; Thompson et al., 2022). This concern remains consistent with past research regarding potential profitability for grassland owners (Ritten, Bastian, and Rashford, 2012). Carbon programs that require ranchers to enroll in a conservation easement are relatively new, so there is limited literature on their preferences for such programs. However, existing

research suggests reluctance among landowners to engage in conservation easements due to concerns about losing managerial flexibility and control, permitting public access, and low financial incentives (A.D. Miller et al., 2010; Bastian et al., 2017).

Ranchers who are not interested in joining the carbon market can still participate in federal and state conservation cost-share programs, which have been the main conduits of promoting the adoption of conservation practices in the U.S. (Canales, Bergtold, and Williams, 2023). Government voluntary programs like the Conservation Reserve Program (CRP) may have higher payouts than agricultural carbon markets. For example, the average rental payment under the CRP was \$74/acre in 2023, whereas the average price of a carbon credit was \$6.51 in the agricultural sector, with U.S. rangelands generating approximately 0.30-0.67 carbon credits per acre (Conservation Reserve Program, 2023; Ecosystem Marketplace, 2024; Ritten, Bastian, and Rashford, 2012). Furthermore, research suggests that farmers generally prefer federally run conservation programs (e.g., CSP, EQIP) over market-based carbon programs (Canales, Bergtold, and Williams, 2023; Thompson et al., 2022). This may be due to limited awareness of carbon market programs, the lack of policies supporting the creation of the carbon market, and negative experiences with previous carbon markets. This research, along with other reported results, highlights the need for diverse types of contracts and payment levels to boost participation in carbon programs (Sharma and Kreye, 2022). Moreover, these results also suggest an important role for educational information aimed at agricultural producers in general to help them make informed decisions.

Future research should explore ranchers' preferences for individual carbon programs. Examining payment characteristic preferences such as whether ranchers prefer annual payments or lump sums every five years, and whether they prefer programs that require conservation easements or demonstrating soil carbon accumulation to receive payments will also be informative. As societal pressure to reduce greenhouse gas emissions grows, there will likely be continued opportunities for ranchers to receive compensation for capturing greenhouse gases on their land. Therefore, facilitating education to increase awareness of existing programs and opportunities, knowing their willingness to join the market, understanding their preferences for carbon program design, and addressing the factors impacting these decisions will all be critical.

FOOTNOTES

1 <https://www.nrcs.usda.gov/resources/data-and-reports/soil-carbon-monitoring-agreements-fiscal-year-2023>

REFERENCES

- Bastian, C.T., C.M.H. Keske, D.M. McLeod, and D.L. Hoag. 2017. "Landowner and Land Trust Agent Preferences for Conservation Easements: Implications for Sustainable Land Uses and Landscapes." *Landscape and Urban Planning* 157(1): 1–13. <https://doi.org/10.1016/j.landurbplan.2016.05.030>.
- Brammer, T.A., and D.E. Bennett. 2022. "Arriving at a Natural Solution: Bundling Credits to Access Rangeland Carbon Markets." *Rangelands* 44(4): 281–290. <https://doi.org/10.1016/j.rala.2022.04.001>.
- Briscoe, M.D., J.E. Givens, S. Olson Hazboun, and R.S. Krannich. 2019. "At Home, in Public, and in between: Gender Differences in Public, Private and Transportation pro-Environmental Behaviors in the US Intermountain West." *Environmental Sociology* 5(4): 374–392. <https://doi.org/10.1080/23251042.2019.1628333>.
- Campbell, S., S. Mooney, J. Hewlett, D. Menkhaus, and G. Vance. 2004. "Can Ranchers Slow Climate Change?" *Rangelands*. 26(4): 16–22.
- Canales, E., J.S. Bergtold, and J.R. Williams. 2023. "Conservation Intensification under Risk: An Assessment of Adoption, Additionality, and Farmer Preferences." *American Journal of Agricultural Economics*. 106(1): 45–75. <https://doi.org/10.1111/ajae.12414>.
- Casaló, L.V., and J.-J. Escario. 2018. "Heterogeneity in the Association between Environmental Attitudes and Pro-Environmental Behavior: A Multilevel Regression Approach." *Journal of Cleaner Production* 175(2): 155–63. <https://doi.org/10.1016/j.jclepro.2017.11.237>.
- Casaló, L.V., J.-J. Escario, and C. Rodriguez-Sanchez. 2019. "Analyzing Differences between Different Types of Pro-Environmental Behaviors: Do Attitude Intensity and Type of Knowledge Matter?" *Resources, Conservation and Recycling* 149(10): 56–64. <https://doi.org/10.1016/j.resconrec.2019.05.024>.
- Conservation Reserve Program. 2023. "Status – End of December 2023." *Conservation Reserve Program (CRP) Statistics*. USDA. <https://www.fsa.usda.gov/resources/programs/conservation-reserve-program/statistics>.
- Derner, J.D., and G.E. Schuman. 2007. "Carbon Sequestration and Rangelands: A Synthesis of Land Management and Precipitation Effects." *Journal of Soil and Water Conservation* 62(2): 77–85.
- Dickinson, B.J., T.H. Stevens, M. Markowski Lindsay, and D.B. Kittredge. 2012. "Estimated Participation in U.S. Carbon Sequestration Programs: A Study of NIPF Landowners in Massachusetts." *Journal of Forest Economics* 18(1): 36–46. <https://doi.org/10.1016/j.jfe.2011.06.002>.
- Dillman, D., J.D. Smyth, and L.M. Christian. 2014. *Internet, Phone, Mail and Mixed Mode Surveys: The Tailored Design Method*, 4th ed. New York: John Wiley and Sons.
- Ecosystem Marketplace. 2022. "Ecosystem Marketplace Insights Brief. The Art of Integrity. State of the Voluntary Carbon Markets." Washington DC: Forest Trends Association. <https://www.ecosystemmarketplace.com/publications/state-of-the-voluntary-carbon-markets-2022/>.
- Ecosystem Marketplace. 2023. "All in on Climate: The Role of Carbon Credits in Corporate Climate Strategies." Washington DC: Forest Trends Association. <https://www.ecosystemmarketplace.com/publications/2023-em-all-in-on-climate-report/>.
- Ecosystem Marketplace. 2024. "State of the Voluntary Carbon Market. On the Path to Maturity." Washington DC: Forest Trends Association. <https://www.ecosystemmarketplace.com/publications/2024-state-of-the-voluntary-carbon-markets-sovcml/>.
- Farmer, J.R., Z. Ma, M. Drescher, E.G. Knackmuhs, and S.L. Dickinson. 2017. "Private Landowners, Voluntary Conservation Programs, and Implementation of Conservation Friendly Land Management Practices." *Conservation Letters* 10(1): 58–66. <https://doi.org/10.1111/cons.12241>.
- Franke, T.M., T. Ho, and C.A. Christie. 2012. "The Chi-Square Test." *American Journal of Evaluation* 33(3): 448–458. <https://doi.org/10.1177/1098214011426594>.
- Han, G., and M.T. Niles. 2023. "Interested but Uncertain: Carbon Markets and Data Sharing among U.S. Crop Farmers." *Land* 12(8): 1526. <https://doi.org/10.3390/land12081526>.
- Jordon, M.W., K.J. Willis, P.-C. Bürkner, and G. Petrokofsky. 2022. "Rotational Grazing and Multispecies Herbal Leys Increase Productivity in Temperate Pastoral Systems – A Meta-Analysis." *Agriculture, Ecosystems & Environment* 33(10): 108075. <https://doi.org/10.1016/j.agee.2022.108075>.
- Kalady, D., P. Thapaliya, A. Dumre, M. Motallebi, M. Alhassan, and E. Van der Sluis. 2024. "Heterogeneity in US Farmers' Preferences for Carbon Payments." *Journal of Agricultural and Resource Economics*. 1–22.
- Kerchner, C.D., and W.S. Keeton. 2015. "California's Regulatory Forest Carbon Market: Viability for Northeast Landowners." *Forest Policy and Economics* 50(1): 70–81. <https://doi.org/10.1016/j.forpol.2014.09.005>.
- Kolady, D., P. Thapaliya, A. Dumre, M. Motallebi, M. Alhassan, and E. Van der Sluis. 2024. "Heterogeneity in US Farmers' Preferences for Carbon Payments." *Journal of Agricultural and Resource Economics* 49(3): 572–592.
- Langpap, C. 2004. "Conservation Incentives Programs for Endangered Species: An Analysis of Landowner Participation." *Land Economics* 80(3): 375. <https://doi.org/10.2307/3654727>.
- Leghari, S.J., N.A. Wahocho, G.M. Laghari, A. HafeezLaghari, G. MustafaBhabhan, and K. HussainTalpur. 2016. "Role of Nitrogen for Plant Growth and Development: A Review." *Advances in Environmental Biology* 10(9).
- Markowski-Lindsay, M., T. Stevens, D.B. Kittredge, B.J. Butler, P. Catanzaro, and B.J. Dickinson. 2011. "Barriers to Massachusetts Forest Landowner Participation in Carbon Markets." *Ecological Economics* 71(11): 180–190. <https://doi.org/10.1016/j.ecolecon.2011.08.027>.
- Miller, A.D., C.T. Bastian, D.M. McLeod, C.M. Keske, and D.L. Hoag. 2010. "Factors Impacting Agricultural Landowners' Willingness to Enter into Conservation Easements: A Case Study." *Society & Natural Resources* 24(1): 65–74. <https://doi.org/10.1080/08941920802684146>.
- Miller, K.A., S.A. Snyder, and M.A. Kilgore. 2012. "An Assessment of Forest Landowner Interest in Selling Forest Carbon Credits in the Lake States, USA." *Forest Policy and Economics* 25(12): 113–122. <https://doi.org/10.1016/j.forpol.2012.09.009>.
- Naioti, E., and E. Mudrak. 2022. "Using Adjusted Standardized Residuals for Interpreting Contingency Tables." *Cornell Statistical Consulting Unit*. <https://cscu.cornell.edu/wp-content/uploads/conttablesid.pdf>.

Nimlos, N., T. Gergen, and J.D. Scasta. 2025. "Rancher Opportunities in Grazing Land Carbon Markets in the United States." *Rangelands*. <https://doi.org/10.1016/j.rala.2025.01.002>.

Ritten, J.P., C.T. Bastian, and B.S. Rashford. 2012. "Profitability of Carbon Sequestration in Western Rangelands of the United States." *Rangeland Ecology & Management* 65(4): 340–350. <https://doi.org/10.2111/REM-D-10-00191.1>.

Sharma, S., and M.M. Kreye. 2022. "Forest Owner Willingness to Accept Payment for Forest Carbon in the United States: A Meta-Analysis." *Forests* 13(9): 1346. <https://doi.org/10.3390/f13091346>.

Shrestha, N.. 2020. "Detecting Multicollinearity in Regression Analysis." *American Journal of Applied Mathematics and Statistics* 8(2): 39–42. <https://doi.org/10.12691/ajams-8-2-1>.

Stanley, P.L., C. Wilson, E. Patterson, M.B. Machmuller, and M.F. Cotrufo. 2024. "Ruminating on Soil Carbon: Applying Current Understanding to Inform Grazing Management." *Global Change Biology* 30(3). <https://doi.org/10.1111/gcb.17223>.

Thompson, N.M., M.N. Hughes, E.K.M. Nuworsu, C.J. Reeling, S.D. Armstrong, J.R. Mintert, M.R. Langemeier, N.D. DeLay, and K.A. Foster. 2022. "Opportunities and Challenges Associated with 'Carbon Farming' for U.S. Row-Crop Producers." *Agricultural & Applied Economics Association* 37(3): 1–10.

USDA, National Agricultural Statistics Service. 2022. "Table 52. Selected Producer Characteristics: 2022 and 2017." *2022 Census of Agriculture – United States Data*, United States 57.

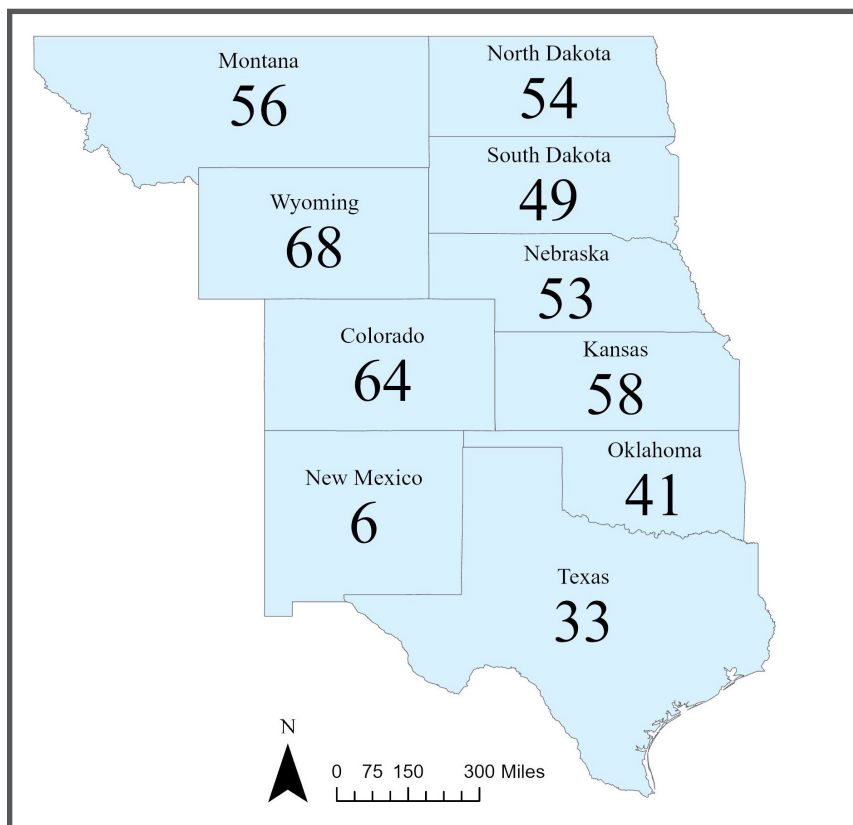


Figure 1. Number of surveys collected from the target population ($n = 482$); 22 respondents did not indicate their location in the survey

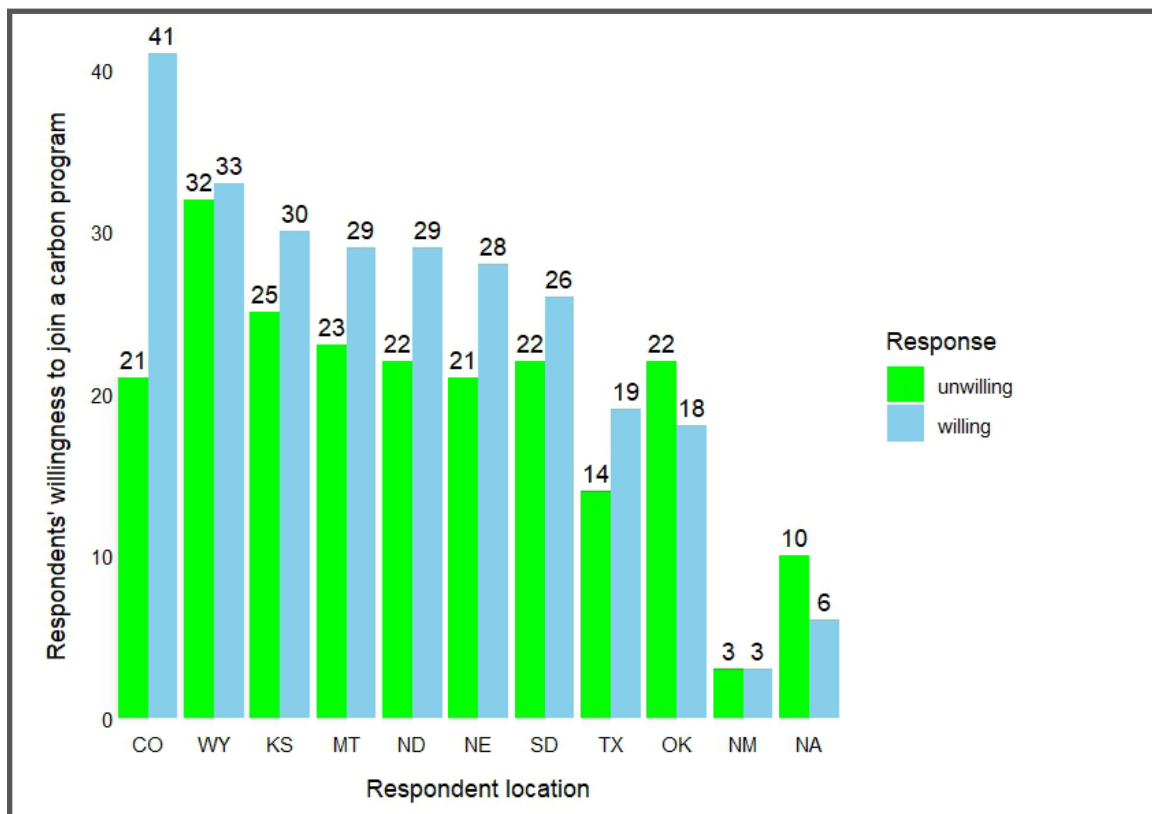


Figure 2. Respondents' willingness to join a carbon program by location ($n = 477$); note: NA represents respondents who did not indicate their location

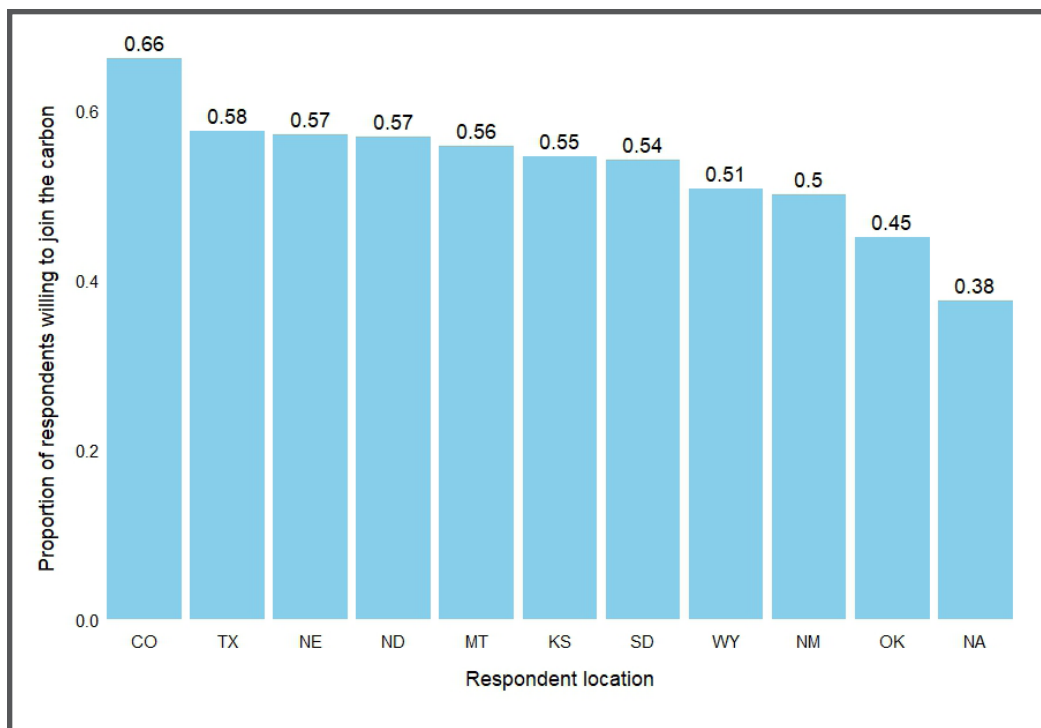


Figure 3. The proportion of respondents willing to join the carbon market by location ($n = 477$); note: NA represents respondents who did not indicate their location

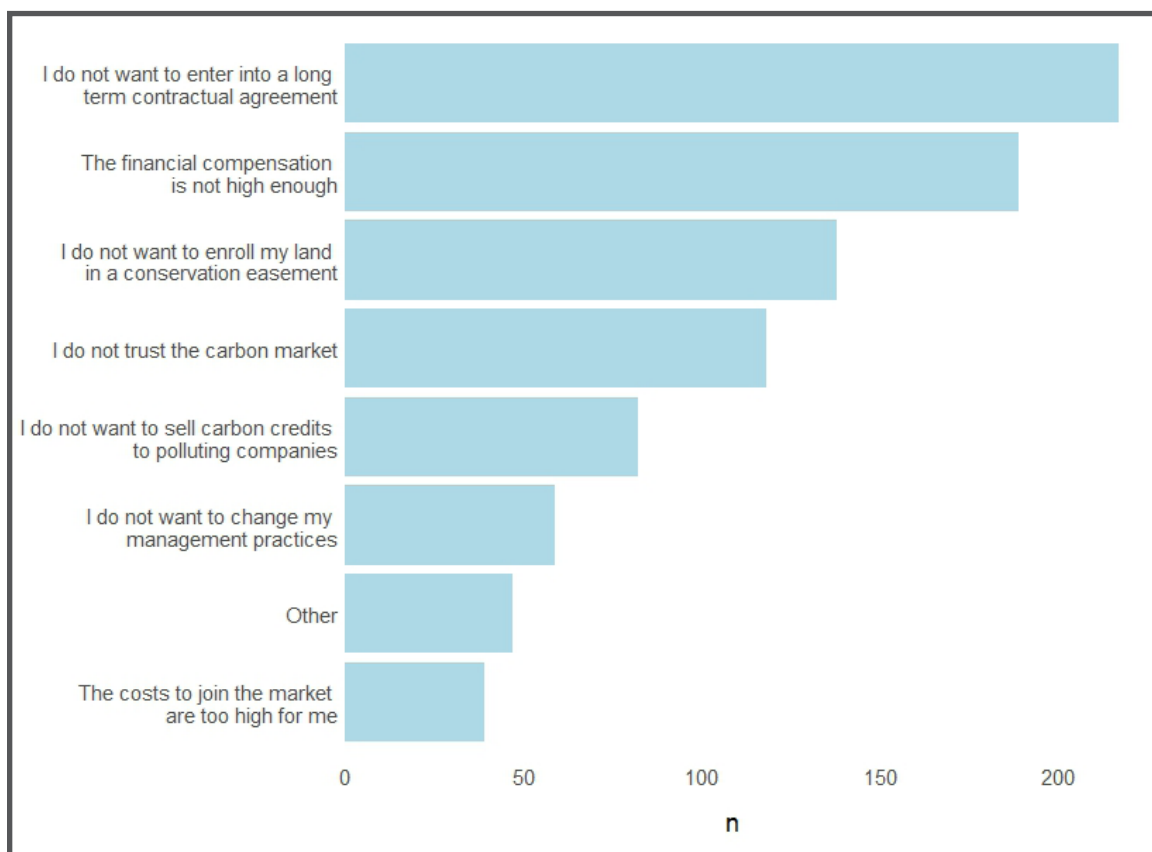


Figure 4. Reasons respondents were unwilling to join a carbon program

Table 1. Survey Respondent Characteristics (n = 504)

	No.	%
Operation type		
Cattle and calves	431	89.42
Hay	283	58.71
Non-hay crop production	134	27.80
Horses, ponies, mules, burros, or donkeys	94	19.50
Other	44	9.13
Sheep or goats	29	6.02
Poultry or eggs	28	5.81
Hogs and pigs	6	1.24
Location		
Colorado	64	13.28
Kansas	58	12.03
Montana	56	11.62
Nebraska	53	11.00
New Mexico	6	1.24
North Dakota	54	11.20
Oklahoma	41	8.51
South Dakota	49	10.17
Texas	33	6.85
Wyoming	68	14.11
Gender		
Male	402	83.75
Female	78	16.25
Age		
18-24	0	0
25-44	25	5.12
45-64	159	32.58
65-84	282	57.79
85 or above	22	4.51

Table 2. Property Sizes and Ownership Types of Survey Respondents (n = 504)

	Mean	Median	Minimum	Maximum	Sum
Leased acres	3,132	988	20	100,000	720,316
Deeded acres	2,297	1,000	6	28,000	957,684

Table 3. Respondents' Awareness of the Voluntary Carbon Market Prior to the Survey (n = 495)

	No.	%
Yes	187	37.78
No	209	42.22
Somewhat	99	20.00

Table 4. Respondents' Interest in Participating in a Grassland Carbon Program (n = 477)*

	No.	%
Selected one of the three programs	262	54.93
Would not be interested in joining any of the carbon programs	215	45.07

* Wald confidence interval for willingness to join the market: (0.50, 0.59)

Table 5. Reasons Respondents Were not Interested in Joining a Carbon Program

	No.	%
I do not want to enter into a long-term contractual agreement	217	43.06
The financial compensation is not high enough	189	37.50
I do not want to enroll my land in a conservation easement	138	27.38
I do not trust the carbon market	118	23.41
I do not want to sell carbon credits to polluting companies	82	16.27
I do not want to change my management practices	59	11.71
Other	47	9.33
The costs to join the market are too high for me	39	7.74

SUPPLEMENTARY MATERIALS

Table S1. Results from the Chi-Square Tests for Variable Independence

	X ²	df	p-value
Age	10.63	3	0.014*
Awareness of market prior to survey	1.96	2	0.38
Gender	0.10	1	0.75
State ^a	5.42	8	0.71

^aNew Mexico was dropped from the analysis due to lack of respondents from this state.

*p<0.05.

Table S2. The Adjusted Pearson Residuals Run Post Hoc of the Chi-Square Test of Independence between Respondent Willingness to Enroll in a Carbon Program and Age

Age Category	Chose not to Select a Carbon program	Selected a Carbon Program
34.5	0.83	-0.83
54.5	-3.06	3.06
74.5	1.96	-1.96
85 or above	1.49	-1.49

Table S3. Multiple Logistic Regression Model to Assess if Enterprise Type, Property Size and Type, and Respondent Location Predict Willingness to Participate in the Carbon Market

Variable	Coefficient (β)	Standard Error	z-value	p-value	VIF ^a
Intercept	-0.82	0.96	-0.85	0.39	
Cattle and calves	-0.24	0.31	-0.77	0.44	1.12
Hay	0.51	0.22	2.36	0.018*	1.15
Hogs and pigs	0.42	1.01	0.42	0.67	1.056
Sheep or goats	-0.031	0.045	-0.068	0.95	1.093
Horses, ponies, mules, burros, or donkeys	0.14	0.26	0.55	0.58	1.075
Poultry or eggs	0.87	0.49	1.81	0.070	1.097
Non-hay crop production	-0.47	0.23	-2.03	0.042*	1.10
Other	0.19	0.36	0.052	0.96	1.076
Private acres	0.00011	0.000038	2.81	0.0049*	1.12
Leased acres	-0.000022	0.000017	-1.34	0.18	1.08
Colorado	1.23	0.95	1.29	0.20	1.03
Kansas	0.88	0.96	0.91	0.36	1.03
Montana	0.59	0.95	0.63	0.53	1.03
Nebraska	0.81	0.95	0.85	0.39	1.03
North Dakota	0.81	0.96	0.84	0.40	1.03
Oklahoma	0.47	0.97	0.49	0.63	1.03
South Dakota	0.60	0.96	0.63	0.53	1.03
Texas	0.94	0.98	0.96	0.34	1.03
Wyoming	0.44	0.94	0.46	0.64	1.03

^a Variance inflation factor for assessing multicollinearity; the calculated VIF values were close to one, implying we had no issues with multicollinearity (Shrestha, 2020).

^b New Mexico was set as the reference level for respondents' location.

*p<0.05.