Introduction & Literature Review

Sustainability has continued to be a focal point of the cattle industry, as both on-farm and public pressures demand increased attention to the three pillars of sustainability: social, environmental, and economic (Greenwood, 2021). Socially and environmentally, the cattle industry has come under public scrutiny for negative climate impacts, such as high levels of greenhouse gas emissions and animal welfare issues (Cargill, 2023; NCBA, 2023; U.S. Environmental Protection Agency, 2023; U.S. Roundtable for Sustainable Beef, 2023). Economically, rising input costs (U.S. Senate Committee on Agriculture, Nutrition, & Forestry, 2023), consumer beef demand, and other financial factors influence the overall cost of production and price of beef in the grocery store. Notably from the social pillar, consumers have had an increased interest in animal welfare and handling on the farm (e.g., grass-fed beef, cage free eggs, etc.) and are increasingly likely to pay more for products produced this way (Spain et al., 2018).

Currently, there are numerous ongoing efforts at the federal (e.g., U.S. plan for Net-Zero Greenhouse Gas Emissions by 2050; The White House, 2021) and industry levels (American Society of Animal Science, 2015; NCBA, 2023; U.S. Roundtable for Sustainable Beef, 2023) intended to move toward more sustainable cattle production practices. Within the cattle industry, specifically, the National Cattlemen's Beef Association (NCBA) has established industry benchmarks related to the three pillars of sustainability, including production climate neutrality by 2040, enhanced opportunities for producer profit and economic sustainability by 2025, and enhancing public trust in cattle producers by the expansion of animal care and handling opportunities (NCBA, 2023). These goals stand as industry-based aspirations that strive to maintain a balance in which cattle producers implement economically profitable and environmentally friendly practices. Sustainable practices should also increase public trust of producers as stewards of the land who raise their cattle responsibly and support the industry's safety and well-being.

Despite its attention, sustainability has not been well-defined in the literature (Whitewood, 2023). However, we utilize the USDA's (2011) Consensus Statement as a definition of sustainability for the current study. This statement presents a balance of the three pillars by stating sustainability encompasses the following elements: 1) satisfying human needs; 2) enhancing environmental quality, the resource base, and ecosystem services; 3) sustaining the economic viability of agriculture; and 4) enhancing the quality of life for farmers, ranchers, forest managers, workers, and society as a whole. Sustainable practices or "best management practices" have been shown to be the most effective, environmentally sustainable, and long-term economically efficient way to manage an operation (Feather & Amacher, 1994; Gillespie et al., 2007; Paudel et al., 2007). While scientists, policymakers, and Extension agents have shared frustration regarding the extent to which producers adopt these practices (King et al., 2017; Pannell et al., 2006), prior literature has shown producers have implemented production practices that seek to achieve sustainable outcomes such as protecting animal welfare, fostering community relations, ensuring succession, promoting human health, engaging genetic technologies, optimizing feed efficiency, and improving reproductive management practices (DelCurto et al., 2005; Gosnell et al., 2021; Menozzi et al., 2015; Mishra et al., 2020; White et al., 2015).

For example, DelCurto et al. (2005) reviewed sustainable grazing practices used by beef producers in the Pacific Northwest, positing ways producers should implement proper grazing

techniques that work to uniformly distribute cattle across the land to maintain or improve land and water health (e.g., breed considerations, using off-stream water sources, and managed seasonal grazing). Gosnell et al. (2020) also emphasized the role managed grazing can have on climate change mitigation, finding that although this is a scientific benefit of managed grazing, producers were more motivated to adopt the technique due to its capacity to "rebuild resilience into the landscape" (p. 1). Mishra et al. (2020) found the two largest adoption barriers were lack of knowledge and perceived difficulty of implementation in their examination of the adoption of sustainable agricultural practices. Further, Menozzi et al. (2015) found farmers' likelihood to adopt sustainable agricultural practices could be predicted based on perceived behavioral control and attitudes.

Those working closely with cattle producers in Extension and conservation roles have also reported that communicating the topic of sustainability to cattle producers can be challenging. The negative connotation is often connected to the environmental pillar of sustainability and its relationship with the term, climate change. The climate-smart aspirations and goals set by many industry organizations have been found to influence producers' pursuit and perceptions toward sustainable practices. Communication about climate change with producers has presented challenges due to the politically charged nature around the term, negative media perceptions, unreliable weather forecasting, and lack of producer trust (Telg et al., 2018). Davidson et al. (2019) found beef and grain producers were most motivated to adopt a climate-mitigative practice by benefits related to economic return, soil quality, and biodiversity, not the belief that cattle production plays a role in climate change.

Despite these challenges, more widespread adoption of practices in all three pillars, social, environmental, and economic, of sustainability is needed to meet current internal, public, and federal expectations. Therefore, it is critical agriculturalists seek innovative strategies to communicate to producers to encourage the pursuit of sustainable outcomes and meet these benchmarks across social, environmental, and economic domains. To aid in the formation of tailored messages, this study sought to understand producers' perceived barriers and benefits to implementing sustainable behaviors on their operations. We draw from the Theory of Diffusion of Innovations (Rogers, 2003) and the framework of social marketing (Lee & Kotler, 2020) to describe adoption perceptions surrounding sustainable practices. The results of this study can inform future tailored communication highlighting the benefits and diminishing the barriers toward sustainable behaviors to encourage long-lasting behavior change and widespread adoption in this area (Campbell & King, 2022; King & Baker, 2018).

Diffusion of Innovations

The Theory of Diffusion of Innovations (DOI) provides a theoretical framework to explain how new technologies, practices, and/or ideas can be spread through a social system (Rogers, 2003), such as sustainable production practices. It focuses on dividing a social system into five categories of adopters based on their level of innovativeness, that is, the degree to which individuals in the group have adopted new practices in comparison to others: 1) innovators, who are the first to adopt due to their ideals as adventurous, risk-takers, and enthusiasts, 2) early adopters, who are more selective than adopters, but embrace new ideas, 3) early majority, who are the 'average' and base decisions on tried and tested results, 4) late majority, who are more skeptical and will adopt because an idea is mainstream and/or a necessity, and 5) laggards, who are last to adopt due to high resistance to change. Rogers (2003) suggested individuals will move

through the innovation-decision process, or a series of stages, as they become aware of an innovation and decide to adopt the innovation. The first stage is known as the 'knowledge stage,' where a person becomes aware of the innovation and how it works. Next, they form an opinion or an attitude about the innovation (persuasion stage). Following, they make the decision to either adopt or reject the innovation (decision stage). Finally, they decide to implement the innovation (implementation stage) and will either continue to use the innovation or reverse their decision (confirmation stage; Rogers, 2003).

Within the innovation-decision process, people take into consideration five factors driving their interests and desire to adopt practices (Campbell & King, 2022; Rogers, 2003). When choosing whether or not to adopt a practice, individuals will consider 1) the main advantages of the new practice over the current practice (i.e., relative advantage), 2) the alignment of the practice with their personal and operational needs and values (i.e., compatibility), 3) the level of complexity and/or difficulty of the new practice (i.e., complexity), 4) if there is an opportunity to test the new practice prior to adopting it at a large scale (i.e., trialability), and 5) if there is an opportunity to observe the results from others through demonstration (i.e., observability; Rogers, 2003). Within the context of sustainability in agricultural production, DOI has frequently been used to understand the behavior change process surrounding adoption of desired production practices, including sustainable cattle practices (Campbell & King, 2022), organic farming practices (Simin et al., 2014), conservation practices in corn production (Asprooth et al., 2023), and practices to support soil health (Hill et al., 2023).

Encouraging Adoption through the Lens of Social Marketing

While the adoption of new practices may take many years, the USDA's and industry-based aspirational goals seek to accelerate the rate at which cattle producers adopt sustainable practices. Our approach is to encourage producers to adopt sustainable practices by applying the framework of social marketing, which is a comprehensive strategy that can be used to guide persuasive communication efforts toward long-term behavior change (Lee & Kotler, 2020; McKenzie-Mohr et al., 2011; Warner, 2014). Social marketing applies integrated strategic communication techniques to encourage behavior change to benefit social good, communities, and the environment (Lee & Kotler, 2020). Substantial evidence exists where social marketing techniques have encouraged key publics to adopt behaviors in areas such as recycling, water and energy conversation, childhood obesity, public health, and water reduction (Andreasen, 2006; Kotler & Lee, 2008; Lee & Kotler, 2020; McKenzie-Mohr, 2011; Warner, 2014). Because the adoption of sustainable on-farm practices benefits the producer and society as a whole, this framework is appropriately applied in this study. Further, the spread of an innovation through a social system has been known to take place through the facilitation of strategic communication to the adopter (Rogers, 2003). Communication interventions, like social marketing, can be used to strengthen DOI by accelerating behavior adoption among audiences. Lee and Kotler (2020) explain this phenomenon:

> The implication of social marketers is that for a relatively new behavior, you start by prioritizing innovators and early adopters and then, once that adoption is successful, move to the early majority and then the late majority. After these groups are on board, the assignment gets easier, as the laggards will be "outnumbered." (p. 89)

Social marketing posits that information-based communication campaigns tend to assume behavior change will occur if sufficient information is provided; however, education alone has little to no effect on creating long-lasting behavior changes (McKenzie-Mohr et al., 2011). Instead, this technique focuses on evaluating audience needs and developing strategic communication (Warner, 2014) as messages that target audience members' values, prior beliefs, perceived key benefits, and motivations have been shown to be more persuasive and effective than information alone (Azjen, 1985; Petty & Cacioppo, 1986).

To accelerate the spread of adoption, communicators and practitioners should consider reasons why producers have not adopted existing practices (i.e., the barriers) and what may influence the adoption of new practices (i.e., the motivations) (Campbell & King, 2022). In the social marketing framework, the main priority for message development is to first understand the audience perceptions and needs (Hine et al., 2014). Using research-based audience needs assessments, communicators can determine the unique set of audience perceptions surrounding a desired behavior, what may prevent them from participating in a behavior, and what might encourage them to participate in the behavior (McKenzie-Mohr et al., 2011). Within the literature, barriers have been defined as 'costs' to the target audience that can consist of internal or external factors relating to the individuals in the group and of behavior that is being studied; whereas, benefits have been described as a desire that the audience can potentially gain in exchange for acting upon the promoted behavior (Lee & Kotler, 2020). Communicators have used this information to their advantage by informing and positioning communication within conservation and sustainability by minimizing the effects of the barriers and emphasizing the benefits as an outcome of adopting a behavior (Sanders et al., 2023; Warner & Schall, 2015).

Studies that have explored the implementation of new practices in beef production and land management have primarily focused on the environmental pillar. For example, prior research has shown producers are interested in the benefits of being stewards of the land and are more likely to adopt practices that support this theme (Davidson et al., 2019; Gosnell et al., 2020). While these studies have highlighted the significance of obtaining information related to the motivations and obstacles faced by producers in order to tailor communication strategy (Campbell & King, 2022; Carolan, 2005; King et al., 2017; Roesch-McNally et al., 2018), more research is needed to understand cattle producer perspectives when incorporating practices that meet the needs of sustainable efforts across the social, economic, and environmental pillars.

Further, data driven strategies may be more strategic and effective because "they are informed heavily by formative audience research which reveals the audience's perceived barriers and motivators to making a desired behavior change" (Warner et al., 2022, p. 2). More specifically, if communicators can understand the underlying motivations producers have toward sustainable practices' relative advantage and compatibility with their operations and diminish the complexity and barriers, they can better position communication efforts to address all three pillars of sustainability rather than just focusing on one or two at a time. Additionally, there are multiple calls for increasing the number of messages tailored to producers addressing the specific motives for adopting sustainable practices that balance the three pillars (King et al., 2017; Orton, 2021). We focus on the first phase of tackling this challenge by describing U.S. cattle producers' current perceptions of sustainable outcomes, level of adoption to achieve these outcomes, their perceived benefits, and their perceived barriers toward adopting sustainable practices.

Purpose and Research Objectives

In order to craft social marketing messages aimed at encouraging cattle producers to adopt sustainable practices, the purpose of this paper was to describe U.S. cattle producers' outcome perceptions, current behaviors, perceived benefits, and perceived barriers toward sustainable behaviors. To do so, the following objectives guided this study:

RO1: Describe producers' perceptions of sustainable outcomes.
RO2: Describe producers' adoption status of social, environmental, and economic sustainable practices.
RO3: Describe producers' perceived benefits toward adopting sustainable practices.
RO4: Describe producers' perceived barriers toward adopting sustainable behaviors.

Methods

A survey instrument was created to examine cattle producers' outcome perceptions, status, benefits, and barriers toward adopting sustainable practices. To collect data, we conducted an intercept survey, where respondents, 18 years or older, of the 2023 Cattle Industry Convention and Tradeshow (CattleCon) were asked to respond to a survey regarding their perceptions of cattle sustainability and its practices. In exchange for their participation, the respondents were given a $6 coupon to use at the convention. This study was approved by Texas Tech University IRB protocol #2022-603. The data reported in this manuscript are part of a larger study, and the variables reported in this manuscript were analyzed independently.

Population and Sample

The population for this study was U.S. cattle producers. A team of researchers attended the Cattle Industry Convention and Tradeshow (CattleCon) in February 2023 to recruit a purposive sample of U.S. cattle producers to respond to a survey about their perceptions of sustainable practices. According to Weisberg (2005), intercept polls and surveys are useful in recruiting purposive groups as they seek to obtain populations of interest at places where they typically attend. A variety of methods were used to recruit potential respondents at the convention including pop-up banners distributed across the convention, PowerPoint slides found at the end of presentations, and flyers with QR codes linking to the survey. Additionally, a team of researchers were housed at a trade show booth, and members of the team would approach potential respondents to ask if they met the qualifications and would be interested in taking the survey. To complete the survey, the respondents could scan a QR code using their mobile device to take the survey at a time of their convenience, or the respondents could take the survey in a quiet area housed at our tradeshow booth, with tables, chairs, and couches, using a researcher-provided iPad. After the completion of the survey, the respondents were asked to present a code to the researchers in exchange for a $6 coupon to be used at the convention.

To be eligible to complete the survey, the respondents were asked a series of questions at the beginning of the survey. To confirm eligibility, we asked respondents if they were 18 years or older, had cattle (beef or dairy) on their operation, and if they had made operation decisions within the last five years. If the respondents selected no to any of the three questions, they were excluded from partaking in the survey; however, they were still given an incentive for their

participation. In addition to meeting the aforementioned criteria, respondents who completed less than 80% of the survey questions were removed from the final sample. The completion rate of the survey was 56.52%, calculated based on how many people opened the survey (n = 138) in comparison to how many people fully completed the survey (N = 78).

Table 1 describes the overall demographic characteristics and key operational characteristics of the cattle producers who answered the survey. Respondents across the U.S. answered our survey, with the most coming from the Plains Region (f = 16, 20.5%) and the least from the Southwest Region (f = 7, 9.0%). The respondents' average age was 46.49 (Minimum: 19, Maximum: 81), 60.3% were male, and the majority of respondents were white (f = 74, 94.9%).

Table 1

Respondent demographic characteristics (N = 78)

Demographic Characteristic	*f*	%
Regionality		
Northeast	10	12.8
Southeast	13	16.7
Midwest[a]	15	19.2
South	9	11.5
West	10	12.8
Southwest	7	9.0
Plains[a]	16	20.5
Operation Type		
Cow Calf	65	83.3
Seed Stock	13	16.7
Stocker/Backgrounder	25	32.1
Auction Market/Cattle Buyer	4	5.1
Feedyard	21	26.9
Packing and Retail	9	7.7
Gender		
Female	31	39.7
Male	47	60.3
Race and Ethnicity		
White	74	94.9
American Indian/ Native American or Alaska Native	2	2.6
Other	2	2.6
Hispanic, Latino, or Spanish Background	3	3.8

Note. Respondents could select all answers that apply for their state location, operation type, and race.

[a] Two respondents had operations in the Midwest Region and the Plains Region

Instrument Development

To develop the survey instrument, we followed the Dillman et al. (2014) guidelines for survey development. Throughout the development process, to enhance face and content validity, we sought feedback on the questionnaire's content and clarity from an expert panel. The members of the expert panel included three industry members, who worked in agricultural sustainability and the cattle industry, and three academic members, who held faculty roles in agricultural communications and animal science. Following the expert panel review and revisions, we also conducted three cognitive interviews with cattle producers to identify any issues in the question wording, order, design, and/or navigation (Dillman et al., 2014). Finally, we conducted a pilot test with a similar population of cattle producers in Texas to ensure the reliability of the instrument and anticipate average timing. We did conduct reliability tests using Cronbach's alpha and found all constructs to have alpha reliabilities greater than .8.

Instrumentation and Variables

Our questionnaire included questions related to cattle producers' outcome perceptions, adoption status, benefits, and barriers toward the adoption of sustainable practices. The questions used to understand the perceived benefits and barriers were researcher-created; however, they were adapted from social marketing literature (Lee & Kotler, 2020), prior research conducted in the cattle industry regarding sustainable practices (see: Bopp et al., 2019; DelCurto et al., 2005; Elias & March, 2019; Gosnell et al., 2020; Greenwood, 2021; Maia de Souza et al., 2017; Menozzi et al., 2015; & Mishra et al., 2018), as well as industry-based research (NCBA, 2023; U.S. Roundtable for Sustainable Beef, 2019), and input and review from our expert panel.

Perceptions of Sustainable Outcomes

Producers' perceptions of sustainable outcomes were measured by giving them a list of outcomes for sustainable agricultural practices. They were then asked if they thought the following outcomes had a social, environmental, and/or economic impact: *improving soil health, increasing renewable energy, improving worker safety, maintaining healthy ecosystems, minimizing antibiotic use, minimizing hormone use, minimizing toxic chemicals, minimizing manure, maintaining the overall welfare of cattle, participating in the community, preserving ranching culture, preserving recreational values, protecting water quality, protecting rivers and streams, reducing climate change, reducing fossil fuels, reducing greenhouse gases, supporting the local economy,* and *transition/succession planning.* Respondents could select more than one type of outcome for the sustainable practice.

Adoption Status of Sustainable Practices

Cattle producers' adoption status of sustainable practices were measured using a 5-point Likert Scale (1 = *I have never adopted this practice*, *2 = I have adopted this practice in the past, but not anymore,* 3 = *I am thinking about adopting this practice in the future*, 4 = *I know I will adopt this practice in the future,* and 5 = *I am currently using this practice*) in response to the statement, "Please reflect upon your likelihood to adopt the following sustainable practices." The cattle producers selected their adoption status to the following statements: *improving soil health,*

increasing renewable energy, improving worker safety, maintaining healthy ecosystems, minimizing antibiotic use, minimizing hormone use, minimizing toxic chemicals, minimizing manure, maintaining the overall welfare of cattle, participating in the community, preserving ranching culture, preserving recreational values, protecting water quality, protecting rivers and streams, reducing climate change, reducing fossil fuels, reducing greenhouse gases, supporting the local economy, and *transition/succession planning.*

Perceived Benefits

Cattle producers' perceived benefits to adopting sustainable practices were measured using a 5-point Likert Scale (1 = *Strongly Disagree;* 5 = *Strongly Agree)* toward the question, "We would like to understand your perceived benefits to adopting sustainable practices. Please select your level of agreement with the following statements as whether you believe each of the statements is a benefit to adopting sustainable practices." The cattle producers selected their level of agreement with the following statements and their benefit toward adoption: *ensuring operation profitability; ensuring positive public perceptions; ensuring financial incentives government payments and/or market incentives; increasing productivity and profitability; maintaining healthy ecosystems; mitigating climate change; protecting the biodiversity of ranch lands; protecting the welfare of cattle; protecting water quality; preserving scarce resources; providing generational succession; providing an opportunity to support more than one family; reducing greenhouse gas emissions;* and *sustaining and maintaining profitability.* We found this construct to be reliable, with a Cronbach's $\alpha = .898$ (Wimmer & Dominick, 2014).

Perceived Barriers

Similarly, the cattle producers' perceived barriers to adopting sustainable practices were measured using a 5-point Likert Scale (1 = *Strongly Disagree;* 5 = *Strongly Agree)* toward the question, "We would like to understand your perceived barriers to adopting sustainability practices. Please select your level of agreement with each of the following statements as whether you believe each of the statements is a barrier to adopting sustainability practices." The cattle producers selected their level of agreement with the following statements and their barrier toward adoption: *changes to equipment and technology; financial concerns and risk; inadequate incentives (i.e., financial incentives, government incentives, and/or market incentives); incompatibility with operation size; lack of knowledge/education on how to adopt sustainable practices; lack of on-farm trials and demonstrations; lack of other cattle producer examples; lack of market for sustainable practices; perceptions of inefficacy;* and *peer pressure to avoid adoption.* We also found this construct to be reliable, with a Cronbach's $\alpha = .832$ (Wimmer & Dominick, 2014).

Data Analysis

SPSS Version 29 was used to analyze the data. In addition to removing respondents who did not meet our requirements (i.e., did not have cattle on their operations; did not make operation decisions), we conducted a listwise deletion and removed respondents who completed less than 80% of the survey (Weisberg, 2005). For questions with missing data, we conducted an optimization procedure, where we assigned the mean imputation for the entire variable to the

missing data (Weisberg, 2005). The descriptive results below are based on means, standard deviations, frequencies, and percentages to answer the aforementioned research objectives. Providing a description of the results allows for a better understanding of what items the producers agreed most or least with (1 = *Strongly Disagree* and 5 = *Strongly Agree*) for each scale.

Results

RO1: Describe producers' perceptions of sustainable outcomes.

We first asked cattle producers to determine what outcomes (social, environmental, and/or economic) they believed sustainable practices had as shown in Table 2. We found producers perceive each practice had an emphasis on one pillar of sustainability; however, it was also found that each practice could fall into all three of the outcome categories. For example. increasing renewable energy had rivaling emphasis between social (n = 33), environmental (n = 43), and economic (n = 36) impact areas. Additionally, it was found that items such as maintaining the overall welfare of cattle was perceived as having both economic (n = 72) and social (n = 43) impacts on sustainability.

Table 2

Producers' Perceptions of Sustainable Outcomes

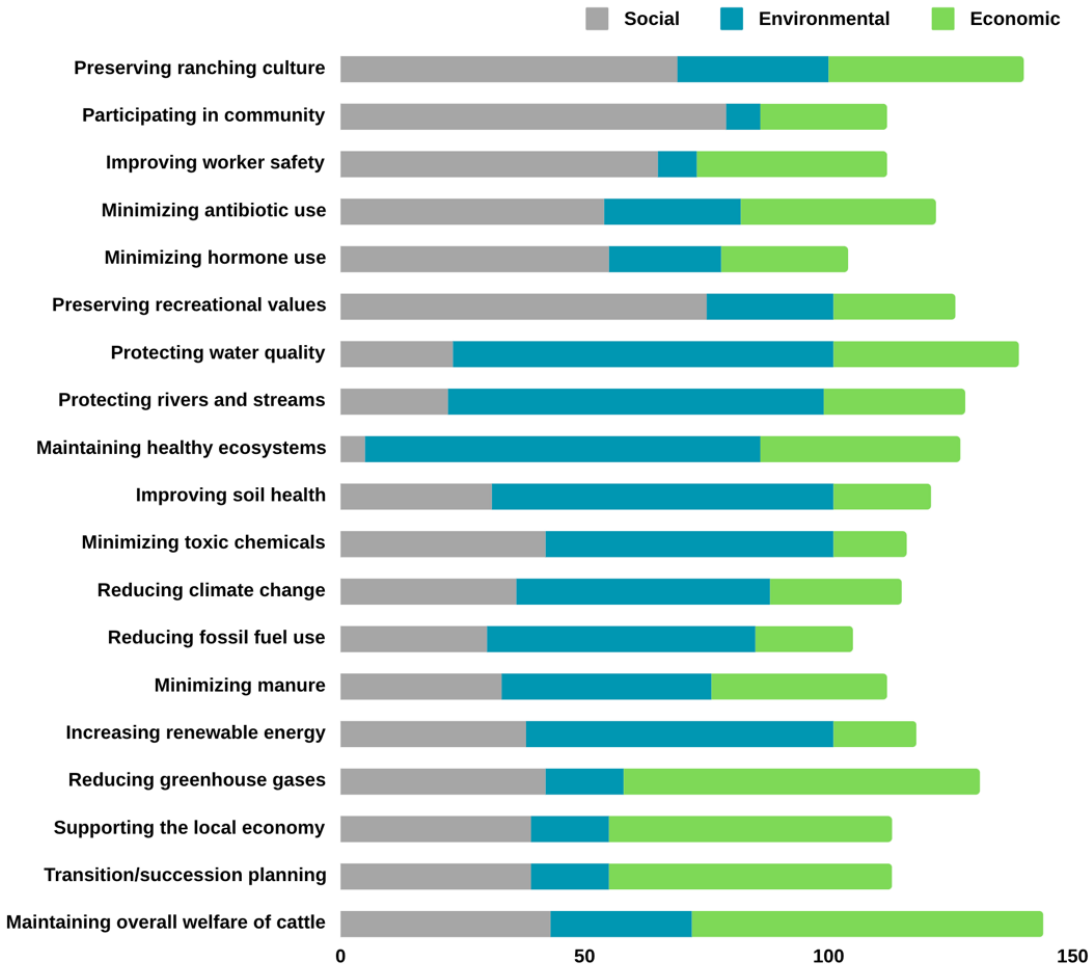
Sustainable Practice	Social *f*	Environmental *f*	Economic *f*	Perceived Primary Outcome
Preserving ranching culture	69	31	40	Social
Participating in community	79	7	26	Social
Improving worker safety	65	8	39	Social
Minimizing antibiotic use	54	28	40	Social
Minimizing hormone use	55	23	26	Social
Preserving recreational values	75	26	25	Social
Protecting water quality	23	78	38	Environmental
Protecting rivers and streams	23	81	28	Environmental
Maintaining healthy ecosystems	22	77	29	Environmental
Improving soil health	5	81	41	Environmental
Minimizing toxic chemicals	31	70	20	Environmental
Reducing climate change	42	59	15	Environmental
Reducing fossil fuel use	36	52	27	Environmental
Minimizing manure	30	55	20	Environmental
Increasing renewable energy	33	43	36	Environmental
Reducing greenhouse gases	38	63	17	Environmental
Supporting the local economy	42	16	73	Economic
Transition/succession planning	39	16	58	Economic
Maintaining overall welfare of cattle	43	29	72	Economic

Note. Respondents could select more than one outcome for each sustainable practice.

As Figure 1 visually demonstrates, producers revealed they viewed the given practices as having more than one sustainable outcome, although one impact is more heavily perceived than others in most instances.

Figure 1

Producer perceptions of social, environmental, and/or economic outcomes



Note. Respondents could select more than one outcome for each sustainable practice.

RO2: Describe producers' adoption status of social, environmental, or economic sustainable practices.

We then asked the cattle producers to reflect upon their likelihood to adopt one or more behaviors to achieve a series of sustainable practices as shown in Table 3. We found producers were more likely to plan to adopt or adopt behaviors focused on social and economic outcomes: supporting the local economy (M = 4.71, SD = 0.90), maintaining the overall welfare of cattle (M = 4.67, SD = 4.67), and preserving ranching culture (M = 4.67, SD = 0.86).

Although we found the majority of the least likely to be adopted behaviors were environmentally focused, such as reducing greenhouse gases (M = 2.73, SD = 1.74) and

increasing renewable energy (*M* = 2.90, *SD* = 1.52), these cattle producers were more likely to plan to adopt or adopt practices focused on the outcomes of protecting water quality (*M* = 4.60, *SD* = 1.52), protecting rivers and streams (*M* = 4.53, *SD* = 1.07), and maintaining healthy ecosystems (*M* = 4.47, *SD* = 1.10).

Table 3

Overall Means and Standard Deviations of the Sustainable Outcomes of Cattle Producers' Practices (N = 78)

Sustainable Practice	*M*	*SD*
Social		
Preserving ranching culture	4.67	0.86
Participating in community	4.60	1.02
Minimizing antibiotic use	4.47	1.10
Improving worker safety	4.46	1.15
Preserving recreational values	4.03	1.44
Minimizing hormone use	3.85	1.57
Environmental		
Protecting water quality	4.60	0.93
Protecting rivers and streams	4.53	1.07
Maintaining healthy ecosystems	4.47	1.10
Improving soil health	4.32	1.23
Minimizing toxic chemicals	4.09	1.52
Reducing climate change	3.09	1.57
Reducing fossil fuel use	3.05	1.73
Minimizing manure	3.03	1.77
Increasing renewable energy	2.90	1.52
Reducing greenhouse gases	2.73	1.74
Economic		
Supporting the local economy	4.71	0.90
Maintaining the overall welfare of cattle	4.67	0.89
Transition/succession planning	4.21	1.25

RO3: Describe producers' perceived benefits toward adopting sustainable practices.

We asked cattle producers their perceived benefits toward adopting sustainable practices as presented in Table 4. We found the respondents perceived protecting water quality (*M* = 4.45, *SD* = 0.66), protecting the welfare of cattle (*M* = 4.41, *SD* = 0.80), and maintaining healthy ecosystems (*M* = 4.31, *SD* = 0.76), as the top three benefits. Whereas, mitigating climate change (*M* = 3.28, *SD* = 1.14) and reducing greenhouse gas emissions (*M* = 3.32, *SD* = 1.11) were among the least important benefits toward adopting sustainable behaviors.

Table 4

Overall Perceived Benefits to Adopting Sustainability Practices of Cattle Producers (N = 78)

Benefit	*M*	*SD*
Protecting Water Quality	4.45	0.66
Protecting the Welfare of Cattle	4.41	0.80
Maintaining Healthy Ecosystems	4.31	0.76
Preserving Scarce Resources	4.31	0.74
Providing Generational Succession	4.29	0.82
Sustaining and Maintaining Profitability	4.29	0.97
Increasing Productivity and Profitability	4.26	0.99
Ensuring Positive Public Perceptions	4.24	0.83
Ensuring Operation Profitability	4.17	1.11
Providing an Opportunity to Support more than one Family	4.14	0.83
Protecting the Biodiversity of Ranchlands	4.08	0.89
Reducing Greenhouse Gas Emissions	3.32	1.11
Mitigating Climate Change	3.28	1.12

RO4: Describe producers' perceived barriers toward adopting sustainable behaviors.

Finally, we asked the cattle producers to identify their perceived barriers toward adopting sustainable practices as shown in Table 5. We found the top three barriers to be financial concerns and risk (M = 4.14, SD = 0.75), changes to equipment/technology (M = 3.68, SD = 0.95), and perceptions of inefficacy (M = 3.64, SD = 0.95). We found the least important barrier toward adoption to be peer pressure to avoid adoption (M = 2.94, SD = 1.06).

Table 5

Overall Perceived Barriers to Adopting Sustainability Practices of Cattle Producers (N = 78)

Barrier	*M*	*SD*
Financial Concerns and Risk	4.14	0.75
Changes to Equipment and Technology	3.68	0.95
Perceptions of Inefficacy	3.64	0.95
Inadequate Incentives	3.62	0.86
Lack of Knowledge/Education	3.59	1.03
Lack of Market for Sustainable Practices	3.59	1.08
Incompatibility with Operation Size	3.54	0.85
Lack of other Cattle Producer Examples	3.45	0.92
Lack of On-Farm Trials and Demonstrations	3.42	1.05
Peer Pressure to Avoid Adoption	2.94	1.06

Conclusions, Implications, and Recommendations

Conclusions & Discussions

Currently, the cattle industry has set numerous goals for sustainability, which seek to provide balance between mitigating negative environmental impacts, the economic viability of agriculture, and societal well-being (i.e., Cargill, 2023; NCBA, 2023; USDA, 2023; U.S.

Roundtable for Sustainable Beef, 2023). However, to ensure these goals are met, cattle producers need to adopt practices that balance all three pillars and meet these sustainable outcomes. While prior literature has examined cattle producer perceptions of sustainability, much research has examined the environmental pillar and perspectives toward climate change (e.g., Gosnell et al., 2021; Telg et al., 2018) and perceptions toward the social pillar (e.g., Gosnell et al., 2021). However, limited research has examined perspectives and message development for holistic sustainable practices that balance the three pillars of social, economic, and environmental. The study at hand sought to provide baseline, formative research on U.S. cattle producers' adoption perceptions to inform social marketing strategy encouraging cattle producers to adopt sustainable behaviors.

Our results indicated cattle producers are most likely to adopt practices that they believe achieve economic and social outcomes, such as supporting the local economy, maintaining the overall welfare of cattle, preserving ranching culture, and participating in community. These findings suggest cattle producers are more likely to adopt practices which have direct benefits on both societal and economic impacts of their operations. For example, producers have been cited as being concerned with the welfare of the cattle they raise (Gosnell et al., 2020), which ultimately relates to economic trade-offs, as cattle who are not cared for properly do not maximize their greatest yield potential. These findings support Gosnell et al.'s (2021) work in social sustainability that infers producers are willing to adopt if there is an economic reward. A unique finding from our study suggests cattle producers prioritize practices that support transition and succession planning. Often, cattle operations are passed down through the family, and if the operation is not profitable, there would not be an opportunity to pass down the operation. This finding may be insightful when crafting communication messages positioned to state the practice assists with transition and succession planning. In terms of DOI's innovation-decision process, cattle producers were aware and had familiarity with practices having economic and social implications (Rogers, 2003).

Considering the environmental pillar of sustainability, our sampled cattle producers were less likely to adopt practices with outcomes focused on increasing renewable energy, reducing greenhouse gas emissions, and mitigating climate change. While cattle producers may be the laggards toward these topics and may be highly resistant to change when using these terms and concepts (Rogers, 2003; Telg et al., 2018), our sampled cattle producers were more likely to adopt practices with outcomes focused on specific environmental impacts such as protecting water quality, protecting rivers and streams, and maintaining healthy ecosystems. These findings are complementary to prior research showing the buzzwords of 'climate-change,' 'climate-smart,' and 'greenhouse gas emissions' do not resonate well with traditional producer groups (Davidson et al., 2019; Telg et al., 2018). However, producers prefer adjacent topics like water quality, soil systems, land management, and ecosystems. Perhaps this relates to Gosnell et al. (2020) and Davidson et al.'s (2019) finding that producers are motivated to be stewards of the land or to maintain or better the land's health. Our findings, intertwined with the work from Gosnell et al. (2020) and Davidson et al. (2019), may suggest communication regarding the environmental pillar of sustainability should be focused on how practices that impact water quality, soil systems, land management, and ecosystems allow cattle producers to be stewards of the land or those who continuously improve the land's health.

Implications & Recommendations for Practice

To accelerate the spread of diffusions of sustainable practice adoption within the cattle industry to meet aspirational goals, we should use communication driven by formative audience analysis research (Warner et al., 2022) to inform producers of the relative advantage and compatibility of sustainable practices, and to seek to provide information that reduces the complexity of sustainable practices (Rogers, 2003). This communication strategy should be informed using the social marketing framework, which focuses on highlighting the benefits or motivating factors toward adoption while decreasing the barriers toward adoption, to encourage long-lasting behavior change (Lee & Kotler, 2020; McKenzie-Mohr et al., 2011; Warner, 2014; Warner et al., 2022).

The goal for communication should be to elevate producers' perceived benefits of the practices, which may lead to increased adoption levels. Based on our findings, we propose communications to cattle producers regarding sustainable practices should prioritize the relative advantage and compatibility of sustainable practices by highlighting how specific practices have benefits related to economic and social outcomes. As we found in our first objective, cattle producers perceive each practice to have an element of each of the three pillars. However, the main driving force behind adoption is the bottom line, or economics, and communicators must prove the economic reward for the adoption of the practice. Thus, when communicating the benefits to producers, social marketing approaches should prioritize the economic and social benefits.

When considering the environmental pillar, agricultural communicators must refrain from using the buzzwords of greenhouse gas emissions and climate change due to their negative connotations. As noted, our findings suggested producers were less likely to adopt practices that utilized buzzwords like climate change and greenhouse gas emissions. Instead, practices with environmental outcomes should be reframed to focus on specific attributes. Our findings suggested environmental outcomes should be communicated with terms such as protecting water quality, maintaining healthy ecosystems, and preserving scarce resources. For example, the EPA (2023) has shown that grazing management has a large relative methane reduction impact, but caution should be taken when advertising this benefit to farmer audiences. Instead, communication should highlight managed grazing's other benefits such as improved soil health, animal welfare, and the economic return of adopting these practices. Notably, economic and societal outcomes were also ranked highly with providing generational succession and sustaining/maintaining profitability, and communication messaging should also intertwine these themes. Because the perceived benefits for practices related to water, animal welfare, and healthy ecosystems were prioritized at a high level, we should also continue to encourage these efforts and position other sustainable practices as positively impacting these outcomes.

Rogers (2003) additionally indicated the innovation-decision process is centralized on reducing the complexity, or perceived barriers to adoption, of the innovations. Our sample of producers reported their main barriers were economically focused on financial concerns and risk, changes to technology, inadequate incentives, and ultimately, perceptions of inefficacy. These findings are similar to Mishra et al.'s (2020) finding that a main barrier to adoption was perceived difficulty of implementation. Further, Gosnell et al.'s (2021) discussion on social sustainability indicated these practices are often difficult to document to their lack of metrics and economic impact. Thus, future communication strategy should work to lower these financial barriers and provide evidence of the economic impact or even suggest the economic reward. The

producers in our study did perceive many of the practices to have economic outcomes, and these must be highlighted in holistic sustainable communications. In addition, producers should be made aware of the abundant incentive programs designed to lower adoption costs (Pineiro et al., 2020). Additionally, there is much ongoing research around the quantification of the impact of sustainable practices on bottom line and environmental benchmarks (Gosnell et al., 2020; Rowntree et al., 2020; Stanley et al., 2018). This data should be communicated to producers in the context of profit and stewardship to perhaps increase adoption motivations by activating the data-driven decision-making process. Moreover, communicators may consider the positioning of these practices to enhance succession and transition planning.

In addition, producers must be able to see how these practices relate to diminished barriers and highlighted benefits through trialability and observability, particularly in their geographic area. This can be accomplished through on-farm trials, field days, and workshops hosted by early adopters that represent the navigation of adoption barriers and the benefits of adoption from the farmer's perspective. Interventions such as on-farm demonstrations and workshops must demonstrate the effectiveness and cost-effectiveness of these practices. These interventions will help to draw attention to producers being able to observe the results developed from others (Rogers, 2003).

Overall, we suggest communication strategy should adopt an integrated marketing approach; where cattle producers may gain knowledge of the benefits through industry-based communication through a variety of techniques such as magazine articles in industry-based magazines, website programming, on-farm events, and other communication platforms. This can allow producers to find and self-select resources that apply to the nature of their operation (e.g., cow/calf vs. feedyard), their geographic area, and their decision-making stage (i.e., persuasion, decision, implementation, and confirmation; Rogers, 2003). Based on our findings, the integrated strategic communication approach should emphasize the benefits of holistic sustainable adoption related to stewardship and impact on bottom line and avoid over connecting these efforts to topics such as climate change. To meet environmental benchmarks specifically, messaging should target how to increase the desire to adopt practices that have a considerable impact on mitigating climate change (e.g., managed grazing) while not marketing the outcomes as related to climate change, renewable energy, and reducing greenhouse gases, since producers were least likely to pursue these outcomes. Finally, attention should be placed on ways to lower financial barriers to adoption, as we found these to be top barriers.

Recommendations for Research

Importantly, this was an initial attempt to understand how U.S. cattle producers perceived benefits and barriers toward sustainable practice adoption. There is much more research needed to fully understand this landscape. We propose additional research studies focus on continued approaches to understanding the types of information cattle producers need and prefer to further expand communication strategy in this area. For example, a mixed approach utilizing Q-Sort methodology and qualitative approaches should also be conducted to understand cattle producers' motivations and information needs toward the adoption of practices. Additionally, the qualitative approaches should focus on the *why* these motivations are integral to the success of communication strategy. Other research should continue to investigate agricultural producers' complex perceptions of sustainability and related topics. Additionally, researchers need to take into consideration that sustainable practices are not solely focused on environmental impacts,

and it is important that we, as researchers, focus on conducting studies that seek to balance the three pillars of sustainability and gain insights on the social and economic factors as well as the environmental factors. Finally, more research needs to focus on developing example messages and interventions and testing the effectiveness of these on producer acceptance and willingness to adopt sustainable practices.

Recommendations for Preparing Future Agricultural Communicators

To better prepare students to take on sustainable challenges, incorporating social marketing frameworks and strategies in a classroom setting is recommended to train future agricultural communicators to communicate to target audiences on societal topics that require behavior change. Implementing courses on social marketing can better equip students with techniques to identify the barriers and benefits to their specified group and utilize a deliberate planning process to tailor their communication strategy, which can be applied to topics other than sustainability. To encourage change within a specialized group, there are several frameworks that are used in the agricultural communications field such as the elaboration likelihood model, diffusion of innovations, and the theory of planned behavior. However, there are several relative frameworks including the health belief model, community-based prevention marketing, social norms, the ecological model, and others that can be explored in the social marketing and agricultural communications realm. Market research of this kind, coupled with corresponding frameworks, can inform effective agricultural communications campaigns that strive to promote long-lasting behavior change that positively benefits society as a whole in the sustainability realm and beyond.

Limitations

We acknowledge that there are limitations to this study. Due to the nature of the intercept survey, respondents were limited to those who attended the national cattle convention, meaning that they could be more proactive in their production endeavors and involved in professional development. Additionally, this study represents a small sample size as we could only attend one day of the convention due to travel and time constraints due to inclement weather. Based on the nature of the intercept survey and the small sample sizes, the data may not be generalizable to a whole population of cattle producers. However, this study provided baseline formative data that can be used to inform future research and strategic communication campaigns targeted toward the adoption of sustainable practices.

References

American Society of Animal Science. (2015). *Grand challenges.* https://www.asas.org/docs/default-source/public-policy/gc_pages_web2015.pdf?sfvrsn=2

Andreasen, A. R. (2006). *Social Marketing in the 21st Century.* SAGE Publications, Inc.

Asprooth, L., Galt, R., & Norton, M. (2023). Transforming the Corn Belt: A recipe for collaborative, farmer-driven research and diffusion of innovation. *Journal of Rural Studies, 103*, 103–133. https://doi-org.lib-e2.lib.ttu.edu/10.1016/j.jrurstud.2023.103133

Ajzen, I. (1985). *From intentions to actions: A theory of planned behavior*. In: Kuhl, J., Beckman, J. (Eds.), Action-control: From cognition to behavior. Heidelberg: Springer. https://link.springer.com/chapter/10.1007/978-3-642-69746-3_2

Bopp, C., Engler, A., Poortvliet, P. M., & Jara-Rojas, R. (2019). The role of farmers' intrinsic motivation in the effectiveness of policy incentives to promote sustainable agricultural practices. *Journal of Environmental Management*, *244*, 320–327. https://doi.org/10.1016/j.jenvman.2019.04.107

Campbell, A., & King, A. E. H. (2022). Choosing sustainability: Decision making and sustainable practice adoption with examples from U.S. Great Plains cattle grazing systems. *Animals,* 12, 286. https://doi.org/10.3390/ani12030286

Carolan, M. (2005). Barriers to the adoption of sustainable agriculture on rented land: An examination of contesting social fields. *Rural Sociology*, *79*(3), 387–413. https://doi.org/10.1526/0036011054831233

Cargill, Incorporated. (2023). *Sustainability.* https://www.cargill.com/sustainability

Davidson, D. J., Rollins, C., Lefsrud, L., Anders, S., & Hamann, A. (2019). Just don't call it climate change: climate-skeptic farmer adoption of climate-mitigative practices. *Environmental Research Letters*, *14*(3), Article 034015. https://doi.org/10.1088/1748-9326/aafa30

DelCurto, T., Porath, M., Parsons, C. T., & Morrison, J. A. (2005). Management strategies for sustainable beef cattle grazing on forested rangelands in the Pacific Northwest. *Rangeland Ecology & Management*, *58*(2), 119–127. https://doi.org/10.2111/1551-5028(2005)58%3C119:MSFSBC%3E2.0.CO;2

de Souza, M., Petre, R., Jackson, F., Hadarits, M., Pogue, S., Carlyle, C. N., ... & McAllister, T. (2017). A review of sustainability enhancements in the beef value chain: state-of-the-art and recommendations for future improvements. *Animals*, *7*(3), 26. https://doi.org/10.3390/ani7030026

Dillman, D. A., Smyth, J. D. & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method.* (4th ed). John Wiley & Sons, Inc.

Elias, M., & Marsh, R. (2019). Innovations in agricultural and food systems sustainability in California. *Case Studies in the Environment, 4*(1), 1–14. https://doi.org/10.1525/cse.2019.002170

Feather, P. M., & Amacher, G. S. (1994). Role of information in the adoption of best management practices for water quality improvement. *Agricultural Economics, 11*(2-3), 159–170. https://doi.org/10.1016/0169-5150(94)00013-1

Gillespie, J., Kim, S. A., & Paudel, K. (2007). Why don't producers adopt best management practices? An analysis of the beef cattle industry. *Agricultural Economics, 36*(2007), 89–102. https://doi.org/10.1111/j.1574-0862.2007.00179.x

Gosnell, H., Charnley, S., & Stanley, P. (2020). Climate change mitigation as a co-benefit of regenerative ranching: Insights from Australia and the United States. *Interface focus, 10*(5), Article 20200027. https://royalsocietypublishing.org/doi/pdf/10.1098/rsfs.2020.0027

Gosnell, H., Emard, K., & Hyde, E. (2021). Taking stock of social sustainability and the U.S. beef industry. *Sustainability, 13*(21). https://doi.org/10.3390/su132111860

Greenwood, P. L. (2021). An overview of beef production from pasture and feedlot globally, as demand for beef and the need for sustainable practices increase. *Animal(15),* Article 100295. https://doi.org/10.1016/j.animal.2021.100295

Hill, N., Starzec, K., Underwood, M., Randolph, L., & Ellis, J. (2023, February 5–6). *Soil health motivations and barriers in the context of the diffusion of innovations theory* [Paper presentation]. National Agricultural Communications Symposium, Oklahoma City, OK. https://www.nacsweb.org/_files/ugd/bd24dd_e4f62c7d7a334c698682d4c9233da7ba.pdf

Hine, D. W., Reser, J. P., Morrison, M., Phillips, W. J., Nunn, P., & Cooksey, R. (2014). Audience segmentation and climate change communication: Conceptual and methodological considerations. *WIREs Climate Change, 5*, 441–459. https://doi.org/10.1002/wcc.279

King, A. E. H., & Baker, L. M. (2018). A perplexing process: Understanding how agricultural producers process best management practice information. *Journal of Applied Communications, 55*(3), 1–17. https://doi.org/10.4148/1051-0834.2190

King, A., Baker, L., & Tomlinson, P. (2017). Community-based grazing marketing: Barriers and benefits related to the adoption of best management practices in grazing systems. *Journal of Applied Communications, 101*(1), 44–55. https://doi.org/10.4148/1051-0834.1013

Kotler, P., & Lee, N. R. (2008). *Social marketing: Influencing behaviors for good.* (3rd ed). SAGE Publications, Inc.

Lee, N. R., & Kotler, P. (2020). *Social marketing: Behavior change for social good.* (6th ed). SAGE Publications, Inc.

McKenzie-Mohr, D. (2011). *Fostering sustainable behavior: An introduction to community-based social marketing* (3rd ed.). New Society Publishers.

Menozzi, D., Fioravanzi, M., & Donati, M. (2015). Farmer's motivation to adopt sustainable agricultural practices. *Bio-based and Applied Economics*, *4*(2), 125–147. https://doi.org/10.13128/BAE-14776

Mishra, B., Gyawali, B. R., Paudel, K. P., Poudyal, N. C., Simon, M. F., Dasgupta, S., & Antonious, G. (2018). Adoption of sustainable agriculture practices among farmers in Kentucky, USA. *Environmental management*, *62*, 1060–1072. https://doi.org/10.1007/s00267-018-1109-3

National Cattlemen's Beef Association. (2023). *Commitment to building a sustainable legacy.* Sustainability. https://www.ncba.org/producers/sustainability

Orton, G. (2021). *Covering Climate Change: A content analysis of climate change message frames in agricultural magazines.* (Master's thesis, Texas Tech University). TTU DSpace. https://hdl.handle.net/2346/887.49

Pannell, D. J., Marshall, G. R., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture, 46*(11), 1407–1424. https://doi.org/10.1071/EA05037

Paudel, K. P., Gauthier, W. M., Westra, J. V., & Hall, L. M. (2008). Factors influencing and steps leading to the adoption of best management practices by Louisiana dairy farmers. *Journal of Agricultural and Applied Economics, 40*(1), 203–222. https://doi.org/10.1017/S1074070800028066

Petty, R. E., & Cacioppo, J. T. (1986). *Communication and persuasion: Central and peripheral routes to attitude change.* Springer Verlag.

Piñeiro, V., Arias, J., Dürr, J., Elverdin, P., Ibáñez, A. M., Kinengyere, A., ... & Torero, M. (2020). A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. *Nature Sustainability*, *3*(10), 809–820. https://www.nature.com/articles/s41893-020-00617-y

Roesch-McNally, G. E., Basche, A. D., Arbuckle, J. G., Tyndall, J. C., Miquez, F. E., Bowman, T., & Clay, R. (2018). The trouble with cover crops: Farmer's experiences with

overcoming barriers to adoption. *Renewable Agriculture and Food Systems*, *33*(4), 322–333. https://doi.org/10.1017/S1742170517000096

Rogers, E. (2003). *Diffusion of Innovations*. (5th ed). New York: Free Press.

Rowntree, J. E., Stanley, P. L., Maciel, I. C., Thorbecke, M., Rosenzweig, S. T., Hancock, D. W., ... & Raven, M. R. (2020). Ecosystem impacts and productive capacity of a multi-species pastured livestock system. *Frontiers in Sustainable Food Systems*, *4*, 232. https://doi.org/10.3389/fsufs.2020.544984

Spain, C. V., Freund, D., Mohan-Gibbons, H., Meadow, R. G., & Beacham, L. (2018). Are they buying it? United States consumers' changing attitudes toward more humanely raised meat, eggs, and dairy. *Animals*, *8*(8), 128. https://doi.org/10.3390%2Fani8080128

Sanders, C. E., Markosyan, T., Gibson, K. E., Byrd, A. R., Lamm, A. J. (2023). Improving sustainable food access and availability in rural communities: An assessment of needed resources. *Sustainability* 2023, *15*, Article 6293. https://doi.org/10.3390/su15076293

Simin, M. T., & Janković, D. (2014). Applicability of diffusion of innovation theory in organic agriculture. *Economics of Agriculture*, *61*(2), 517–529. http://dx.doi.org/10.22004/ag.econ.175298

Stanley, P. L., Rowntree, J. E., Beede, D. K., DeLonge, M. S., & Hamm, M. W. (2018). Impacts of soil carbon sequestration on life cycle greenhouse gas emissions in Midwestern USA beef finishing systems. *Agricultural Systems*, *162*, 249–258. https://doi-org.ezproxy.ttuhsc.edu/10.1016/j.agsy.2018.02.003

Teague, W. R., Dowhower, S. L., Baker, S. A., Haile, N., DeLaune, P. B., & Conover, D. M. (2011). Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie. *Agriculture, ecosystems & environment*, *141*(3-4), 310–322. https://doi-org.ezproxy.ttuhsc.edu/10.1016/j.agee.2011.03.009

Telg, R. W., Lundy, L., Wandersee, C., Mukhtar S., Smith, D., Stokes, P. (2018). Perceptions of trust: Communicating climate change to cattle producers. *Journal of Applied Communications, 102*(3), 1–12. https://doi.org/10.4148/1051-0834.2207

U.S. Senate Committee on Agriculture, Nutrition, & Forestry. (2023). *Revisiting farm production expenses.* https://www.agriculture.senate.gov/newsroom/minority-blog/revisiting-farm-production-expenses

U.S. Environmental Protection Agency. (2023, August 25). *Practices to reduce methane emissions from livestock manure management.* Greenhouse Gas Emissions. https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

U.S. Department of Agriculture. (2011). *Definitions: Sustainability and food systems.* https://www.usda.gov/oce/sustainability/definitions#:~:text=USDA%20Consensus%20Statement%20(2011)%3A,agricultural%2C%20forest%20and%20range%20systems

U.S. Roundtable for Sustainable Beef. (2023). *USRSB high-priority indicator goals & sector targets*. https://www.usrsb.org/goals

U.S. Roundtable for Sustainable Beef (2019). *U.S. Beef Industry Sustainability Framework.* https://www.beefsustainability.us/Media/SustainableBeef/Docs/master_030220_framework_-final.pdf

Warner, L. A. (2014). Enhancing the capacity to create behavior change: Extension key leaders' opinions about social marketing and evaluation. *Journal of Agricultural Education, 55*(4), 176–190. https://doi.org/10.5032/jae.2014.04176

Warner, L. A., & Schall, W. L., (2015). Using social marketing principles to understand an Extension audience's landscape water conservation practices. *Journal of Human Sciences and Extension, 3*(1), 4. https://doi.org/10.54718/WQFF9307

Warner, L. A., Krimsky, L. S., & Rampold, S. D. (2022). Using a diffusion of innovation lens to understand homeowner support for septic system to sewer system conversations. *Journal of Environmental Management, 319,* Article 115651. https://doi.org/10.1016/j.jenvman.2022.115651

The White House. (2021). *The long-term strategy of the United States: Pathways to net-zero greenhouse gas emissions by 2050*. https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf

Weisberg, S. (2005). *The Total Survey Error Approach: A Guide to the New Science of Survey Research.* The University of Chicago Press. Chicago.

White, R. R., Brady, M. Capper, J. L., McNamara, J. P., & Johnson, K. A. (2015). Cow-calf reproductive, genetic, and nutritional management to improve the sustainability of whole beef production systems. *Journal of Animal Science, 93*(6), 3197–3211. https://doi.org/10.2527/jas.2014-8800

Whitewood, T. (2023). *Rural sustainability and agriculture on the Texas High Plains* (Master's thesis, Texas Tech University). TTU DSpace. https://hdl.handle.net/2346/96402

Wimmer, R. D., & Dominick, J. R. (2014). *Mass media research: An introduction.* (10th ed). Cengage Learning.