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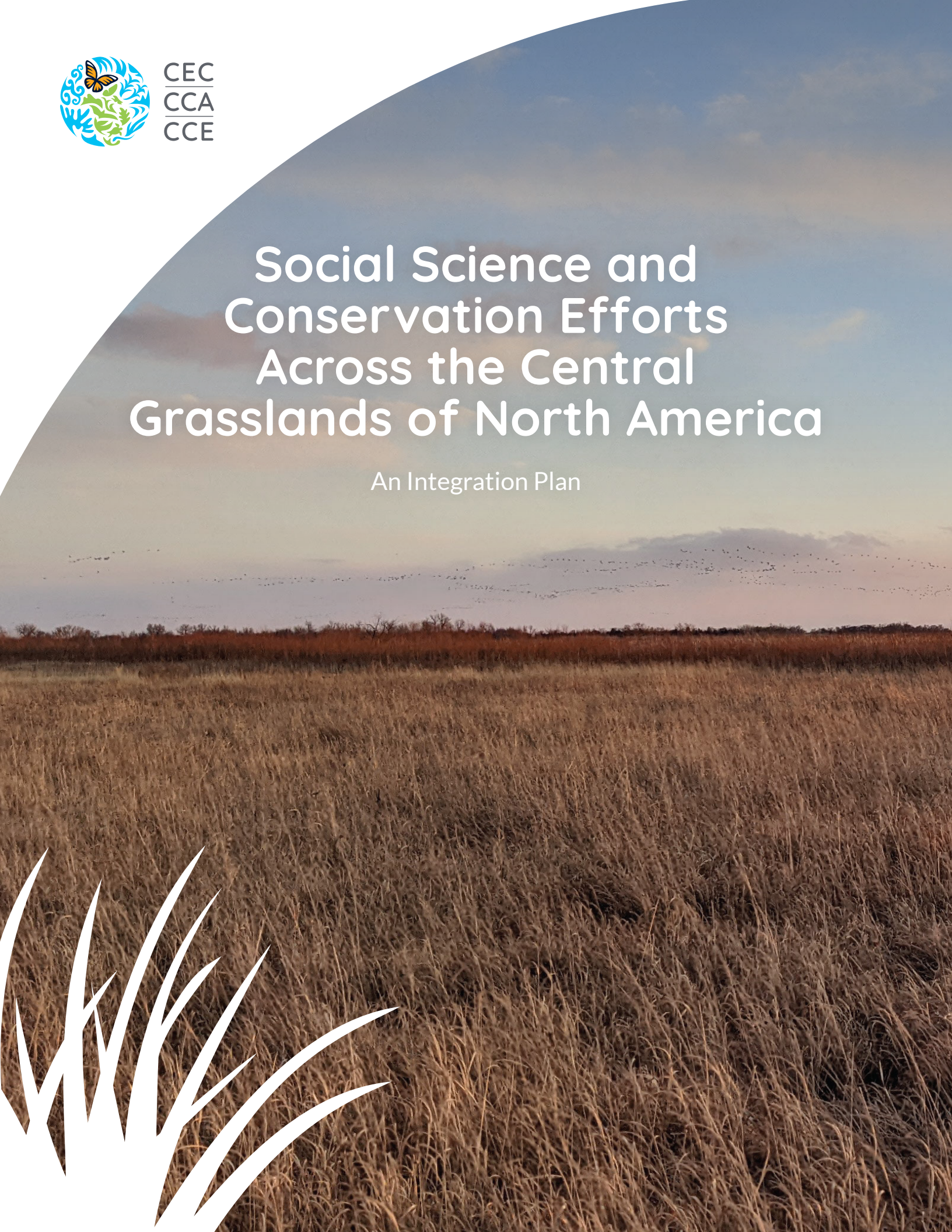
Social Science and Conservation Efforts Across the Central Grasslands of North America

An Integration Plan



Please cite as:
CEC. 2026. Social Science and Conservation Efforts Across the Central Grasslands of North America: An Integration Plan. Montreal, Canada: Commission for Environmental Cooperation. xiii + 67 pp.

This publication was prepared by Playa Lakes Joint Venture for the Secretariat of the Commission for Environmental Cooperation. The information contained herein is the responsibility of the author and does not necessarily reflect the views of the CEC, or the governments of Canada, Mexico or the United States of America.

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ISBN: 978-2-89700-376-0
Disponible en français – ISBN: 978-2-89700-433-0
Disponible en español – ISBN: 978-2-89700-432-3

Legal deposit – Bibliothèque et Archives nationales du Québec, 2026
Legal deposit – Library and Archives Canada, 2026

Cover photo: Migrating Sandhill Cranes across a grassland in Central Nebraska; Ashley Gramza

Publication Details
Document category: Project publication
Publication date: April 2026
Original language: English
Review and quality assurance procedures:
Final review by the Parties: January 2026
QA396
Project: Operational Plan 2021 / Grasslands Conservation and Migratory Birds

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List of Abbreviations and Acronyms

CEC	Commission for Environmental Cooperation
CO_2	carbon dioxide
HCH	hexachlorocyclohexane
INECC	*Instituto Nacional de Ecología y Cambio Climático* (National Institute of Ecology and Climate Change)
INEGI	*Instituto Nacional de Estadística y Geografía* (National Institute for Statistics and Geography)
Semarnat	*Secretaría de Medio Ambiente y Recursos Naturales* (Ministry of the Environment and Natural Resources)

Abstract

The Central Grasslands of North America provide vital habitats for numerous species, yet they are under significant threat from conversion to cropland, renewable energy development, climate change, and invasive species. Despite ongoing efforts, grassland loss continues at a rapid pace. People depend on the Central Grasslands for livelihoods, agriculture and ecosystem services, making it critical to understand land management decisions across these landscapes for successful conservation. However, social science research on grassland management and conservation often lacks coordination and integration within programs or policy, creating a research-implementation gap. Without a clear agenda to prioritize and coordinate practical social science research or plan to communicate results, new insights won't lead to the changes needed to protect grassland biodiversity and ecosystem services. To help understand this implementation gap, provide a robust foundation for future work, and coordinate and prioritize grassland conservation social science, three interrelated efforts were conducted: 1) a literature review of conservation social science related to landowner and land steward decision-making across the Central Grasslands; 2) a synthesis of pre-existing ranchers, producers and landowners surveys to understand the challenges and opportunities for conservation in Canada, Mexico and the United States; and 3) a social science needs assessment and prioritization effort, gathered through an iterative, modified Delphi process. Findings from these efforts were synthesized into this integration plan, identifying information and knowledge gaps, as well as opportunities for integrating social science into grassland conservation delivery, to more effectively address the decline of the Central Grasslands.

Executive Summary

A social science gap analysis was conducted for grassland management. It identified applied social science research priorities for conservation delivery professionals, and developed an integration plan recommending strategies to incorporate social science into Central Grasslands conservation efforts. This work was completed in two key steps:

1) Information from data collected and synthesized through:
    - Meetings with social scientists.
    - A summary of country-specific surveys from the perspectives of ranchers, producers and landowners on grassland conservation initiatives in Canada, Mexico and the United States (CEC, 2025).
    - A literature review providing social science insights on grasslands management practices (CEC, 2026).
    - A needs assessment Delphi process, with conservation delivery professionals.
2) Findings and results related to communication gaps and knowledge gaps, research needs, and opportunities for integrating social science integration with social scientists and conservation delivery professionals, were presented to refine the integration plan.

This summary focuses on the conservation delivery, professional social science needs assessment Delphi process, gap analysis, research priorities, and integration plan, as results from surveys and the literature review have been detailed in separate publications (CEC, 2025; CEC, 2026).

Social Science Needs Assessment Delphi Process: Key Results

Using a modified Delphi process, three rounds of online surveys were conducted to identify effective landowner and community engagement strategies and social science research needs for grassland conservation delivery practitioners. Participation included:

- 78 responses to the initial survey.
- 58 responses to the second survey (a 74% response rate).
- 36 responses to the third survey (a 62% response rate).

Respondents represented the entire Central Grasslands region.

Opportunities to Enhance Conservation Professionals' Understanding of Social Science

Knowledge and Decision-Making:

- Many respondents assumed a knowledge-deficit among landowners and managers on the outcomes of grassland management. They also suggested that with such knowledge, landowners and managers might choose more sustainable management or production systems. Although this is likely the case in some instances, there are many factors that contribute to any decision, and solely increasing the knowledge of outcomes among landowners and managers may have less impact than expected or assumed.
- Economic considerations were consistently highlighted as a key research topic. Many responses centered on the relative role of economic factors in decision-making, highlighting the need for interdisciplinary studies examining the interplay of economic and non-economic factors.

Policy and Engagement:

- Social science can support shifts in agricultural policies to elevate the importance of grasslands and support their conservation such that grassland-based agriculture becomes sustainable, both financially and ecologically. Although not many conservation delivery professionals currently have this purview, and it may take years to achieve it, ensuring that practitioners continue to communicate with local agricultural policy makers about the importance of grasslands and give recommendations for policy changes, this is important and will increase support for grassland conservation and keep producers on the landscape.

Information and Communication Gaps

Several social science research topics, information, and communication gaps were identified as important by conservation delivery professionals. These topics have been extensively studied and are available in peer-reviewed literature, yet they may not be readily accessible to professionals. These include:

- **Grassland conservation actions,** such as prescribed burning and voluntary assistance programs related to grassland conservation, have been extensively studied. However, conservation delivery professionals recognized that understanding human decision-making affecting specific grassland conservation practices was also an important need.

- **Common barriers to grassland conservation behaviors** have also been studied widely, including limitations of ability, time and money; concerns about safety and weather related to prescribed burning; and complexity, bureaucracy, and perceived inflexibility of voluntary grassland conservation assistance programs. Economic constraints and costs of transactions have also been identified as hindering effective management.
- **Predictors of grassland conservation behaviors** were also mentioned as important research needs among grassland conservation delivery professionals, yet have been extensively studied. Positive attitudes regarding management, along with a sense of moral responsibility to conserve grasslands, and positive prior management experience, have been associated in the literature with increased willingness to engage in conservation activities.

Efforts should be made by social scientists to make these available to conservation delivery professionals and/or to summarize them in a form that they prefer and is easy to apply to their work.

Knowledge Gaps and Research Needs

Knowledge gaps and research needs include topics that are understudied but deemed important for future study by both conservation delivery professionals and social scientists, alike. They include:

- **Testing or evaluating specific conservation strategies**. This approach would provide robust research results in a way that may be more familiar to conservation professionals and ranchers.
- Research that includes **multiple analytical scales.** Many studies have focused on individual grassland managerial decisions, community-level decisions or, by inference, on a nationwide scale, but relatively few have addressed grassland management behavior across multiple scales.
- **Interdisciplinary and cross-social science domain analyses.** Identifying research needs in relation to the relative roles of economic and non-economic factors used in predicting or understanding a given grassland conservation action has rarely been studied, it seems, and relatively few such studies were revealed by the literature review. Possibly, this is due to the relative rarity of collaborations among scientists across multiple social science disciplines (e.g., social psychology, anthropology, rural sociology, economics etc.).
- **Social science studies about specific management actions**. Chemical and mechanical treatments for non-native plants, mulching, and mixed-species herbivory to reduce

woody plants, **or emerging and innovative management approaches**, such as the development of new industries that incentivize grassland conservation, can help alleviate some of the economic constraints related to conservation.

These gaps represent a list of research topics for which studies are needed and have the potential for impactful future research. And of course, researchers are encouraged to continue consulting with conservation practitioners throughout the research process.

Research Prioritization

Key research themes and topics prioritized by conservation delivery professionals include:

1. **Understanding the sustainability of agricultural production in grasslands across the domains of economics, production and environment:**
   - Collecting economic data that demonstrates grassland agriculture's sustainability, including the environmental benefits of well managed grasslands, and their measurable economic impacts.
   - Determining how to develop voluntary grassland conservation programs that increase the value of land, based on multiple factors like net productivity and environmental or recreational services.
   - Determining the size of incentives or payments for ecological goods and services that are required to meaningfully reverse the current loss of grasslands and wildlife habitat within them.
   - Determining how landowners can best achieve a balance between conservation, management and production.

2. **Understanding the social and ecological decision-making context of agricultural production on grasslands:**
   - Examining what happens to the economics of grassland conversion compared to other land use types when federal insurances and subsidies are removed.
   - Understanding agricultural producers' perceptions of grassland versus cropland profitability, including when federal insurance and subsidies are removed.
   - Determining what it would take to convince landowners to implement grassland restoration and conservation practices on their properties instead of other land uses.

3. **Examining and evaluating the effectiveness of conservation delivery professionals and longevity of grassland conservation programs:**

- Determining the critical steps that conservation delivery specialists are missing when developing relationships with landowners that are hesitant to work with agencies on grassland improvements.
- Understanding post-grassland management practice behavior to support grassland persistence and how to bridge the gap between different voluntary grassland conservation programs or help landowners plan for the future once income from incentive payments end.
- Understanding how to promote grassland landownership and management persistence to reduce the churn rate of grasslands that are converted to other land uses and keep large grassland blocks together.

These priorities serve as a starting point for discussion between social scientists who may conduct this research and conservation professionals, grassland managers, ranchers and others who will use the data and potentially be affected by the research. Such engagement will necessitate inclusion of the diversity of grassland stewards, including non-white ranchers, Indigenous Nations, and all communities who rely on the Central Grasslands for food, fiber, livelihoods, and essential ecosystem goods and services.

Integration Recommendations

Areas for which social science can be integrated in conservation delivery in the Central Grasslands include:

- **Integrate insights and findings from geographically relevant social science and communications studies into conservation delivery practitioner trainings** both during formal coursework and while being onboarded in a new position.
- **Improve recruitment and retention of conservation delivery professionals** by changing the qualifications required to secure these positions, hiring people embedded within the communities, and evaluating employees using community engagement metrics rather than just grassland acres.
- Partner with social scientists to **understand and evaluate what characteristics make a successful conservation delivery practitioner** and how this might change, based on regions.
- **Create more opportunities for social scientists and grassland conservation delivery practitioners to interact, communicate, and collaborate** so that information is made

available and applied by conservation delivery practitioners and that social scientists can continue to conduct research that fills gaps in grassland social science knowledge.

Effective grassland conservation efforts must employ both top down and bottom up approaches to maximize effectiveness and return on investment while also building trust and promoting the value of grasslands at the individual and community level. Programs must be flexible to the needs of individuals or communities while occurring within a broader regional, national, or multinational context.

Conclusions

Conservation of the Central Grasslands will depend on understanding decisions that are multidimensional and complex, requiring the synthesis of information from the social and biological sciences, Indigenous ways of knowing, and local knowledge. While social science is just one information source, it is essential because human communities are inextricably linked to grasslands and their conservation. This work represents a foundation for the coordinated integration of social science into grassland conservation, but it is not exhaustive and has limitations. This project and others like it have created a broad network of social scientists and conservation delivery professionals who are interested in implementing recommendations for integration and bridge social science knowledge and information gaps. Implementing these recommendations will be essential in conserving the Central Grasslands.

Acknowledgments

We would like to thank all of the social scientists, conservation delivery professionals, bird conservation professionals, and grassland managers who contributed their thoughts and feedback to this effort. Without their time and participation, this work would not have been possible. We'd also like to thank the Commission for Environmental Cooperation (CEC) Project Steering Committee for providing valuable feedback on this important effort and helping us get this across the finish line.

1 Introduction

The Central Grasslands of North America, stretching from southern Canada to northern Mexico (Figure 1), are vital habitats for numerous bird and wildlife species (Keyser et al., 2019). These grasslands are under significant threat from factors like conversion to cropland, renewable energy development, climate change, and invasive species, endangering the grassland ecosystem and many grassland-obligate species (Stephens et al., 2008; Keyser et al., 2019). Grassland birds are particularly vulnerable to these human-induced changes, with over 700 million breeding individuals lost since 1970 (Rosenberg et al., 2019). As bird population status is one indicator of ecosystem health, these declines have spurred action by the conservation community.

Despite ongoing efforts, grassland loss continues at a fast rate, and traditional conservation methods have struggled to halt the decline of grassland-dependent bird species (Augustine et al., 2021). People are reliant on the Central Grasslands for food, fuel, and fiber production, making land management decisions by individuals and communities critical to conservation success. Therefore, conservation professionals must increasingly focus on understanding land management decision-making across these landscapes to stop these declines (Coon et al., 2020; Hoffman et al., 2021a).

Figure 1. Map of the Central Grasslands

Sources: ESRI; World Wildlife Fund.

Given these challenges, a shift in the approach of conventional conservation strategies in the Central Grasslands is clearly needed. The social and ecological contexts of grassland management in Canada, Mexico and the United States also vary significantly, emphasizing the need for informed management decisions. Canada has a complicated mix of private and public land ownership, while in the United States, most grasslands are privately owned. In Mexico, private ownership is rising, but much land is still managed collectively through ejidos (Hruska & Toledo, 2017). This variation necessitates collaborative conservation efforts with grassland-dependent individuals and communities, directing more resources towards approaches that integrate the social and ecological sciences.

Despite recognizing this need, social science research on grassland management and conservation often lacks a coordinated, real-world application, such as integration within programs or policy (Knight et al., 2008). Lacking application for social science results creates a persistent gap in implementing research that is often reflected in broader conservation efforts (Knight et al., 2008). University faculty and students, especially those faculty in tenure-track positions, typically lack support, time, funding, and even the incentive to fully integrate research findings after project completion. On the other hand, conservation professionals and managers frequently lack access to peer-reviewed literature and are excluded from research processes, widening this gap. Without a clear agenda to prioritize practical social science research or a plan to communicate results and coordinate future efforts, generating new insights will not lead to the changes that might protect grassland biodiversity and ecosystem services.

To help understand this potential social science research-to-conservation delivery gap or provide a robust foundation for future work, and coordinate and prioritize grasslands conservation social science efforts, current and past social science literature related to grassland conservation management was reviewed and summarized and a social science needs assessment of grassland conservation practitioners across the Central Grasslands was conducted. This work involved using three approaches:

1) A summary of pre-existing survey efforts to understand the challenges and opportunities for conservation identified by rancher respondents in Canada, Mexico and the United States.

2) A literature review of conservation/social science related to landowner and land steward decision-making across the Central Grasslands. This included peer-reviewed and gray literature, along with conversations and a research inquiry with grassland social science researchers to determine current social science research being conducted related to grasslands.
3) A social science needs assessment and prioritization effort, with an iterative, modified Delphi process to gather information about conservation challenges, opportunities, and social science information needs of grassland managers, and to prioritize those needs to guide future efforts.

Findings from the three efforts were synthesized into this integration plan, identifying opportunities and challenges for grassland conservation delivery, gaps between applied social science needs as identified by practitioners and current literature, and recommendations for where social scientists should prioritize their efforts to benefit grassland conservation through improved conservation delivery and community engagement. The overall goal was to outline a plan, which can be promoted and used by conservation practitioners and social scientists alike, to integrate social science into efforts to address the decline of grassland ecosystems.

2 Summary of Contributing Efforts

2.1 Summary of Ranchers, Producers and Landowners Surveys in Canada, Mexico and the United States

Following a survey conducted by the Central Grasslands Roadmap in the Great Plains region of the United States (The Central Grasslands Roadmap, 2021), the Commission for Environmental Cooperation (CEC) funded two independent surveys of land managers and grassland-based agricultural producers in the prairie biome of Canada and the grassland regions of northern Mexico. In this portion of the project, the results of these three surveys were analyzed to understand what challenges and opportunities were similar across these three broad regions of the Central Grasslands biome (CEC, 2025). Although all the surveys contained the same thematic areas of program engagement, metrics, program needs and suggested messaging, the differences were too great to enable question by question comparisons or allow direct comparisons due to the survey logic, question wording and context (e.g., different programs available).

Due to the limitations outlined above, by necessity, comparisons focused across surveys to a thematic analysis of general patterns. Such an approach to interpretation can complement the other engagement efforts of the Central Grasslands Roadmap (e.g., the 2020 virtual and 2022 in-person summits, and subsequent conversations). Inference was kept quite conservative to reduce the potential for misleading interpretations of survey-to-survey congruities. Nevertheless, it was possible to identify common and unique themes that emerge from the studies and barriers and opportunities for engagement:

Coordinated, face-to-face communications: Landowners, producers, and ranchers in all three countries preferred in-person meetings and events for gathering information about programs. Engagement efforts at the scale of the Central Grasslands will need to be well coordinated, so that activities at the local level are included within larger efforts among the different countries.

Social science-based information: As the conservation initiatives in the Central Grasslands will continue to be developed, more effort should be devoted within different regions to aid understanding of the local contexts of the ranchers, producers, land managers and land stewards. Efforts to account for the social dimensions of conservation will require significant resources and social science expertise to ensure that samples are representative of the populations and regions of interest. Engaging with diverse communities is a key component of this engagement.

Rewarding the good: Land managers, producers, and ranchers view themselves as stewards of the lands and of their communities. Programs that seek to foster the conservation of the Central Grasslands should prioritize engaging with land managers in this role, as guided by communities. In relation to programs, many survey respondents suggested that aligning program-based incentives to reward beneficial conservation and human well-being outcomes rather than those that restrict land management options will likely result in more interest and enrollment.

Acknowledging the good: Survey respondents feel that they are providing a key role in the conservation of the Central Grasslands but that this is not always well communicated to the public and agencies. Where appropriate, documenting and communicating these positive impacts via social and ecological metrics would be viewed as helpful.

These survey results should not be used as an endpoint for engagement, but rather as a starting point, or other data point that can be used for understanding the complex views and perspectives of ranchers, agricultural producers, and land managers in the Central Grasslands. These results can be particularly useful, as conservation practitioners and others seek to develop communication, outreach, and conservation delivery campaigns, to encourage conservation behaviors among these stakeholder groups. These surveys, and this comparison effort, also highlight areas for future social science-based efforts to probe more deeply a given community, region, or themes that have emerged in these surveys.

Ultimately, these findings can continue to be integrated into the Central Grasslands Roadmap and other conservation efforts. The United States survey results were used to inform the 2020 virtual summit and, subsequently, the 2022 in-person summit. Recognizing the predominantly Western bias in inputs, such as the land manager surveys, in the creation of Central Grasslands Roadmap process, the CEC and other funders supported the participation of Indigenous delegates, helping to establish an Indigenous working group, which developed into the Indigenous Kinship Circle (IKC). The IKC's efforts to improve diversity and equity in social science integration also led to the formation of a Socioecological Working Group.

2.2 A Review of Social Science in Grassland Conservation

This review of grassland conservation social science proceeded in a variety of ways. First, a structured literature review was developed to encompass past peer-reviewed research (CEC, 2026). Two virtual discussions with grassland social scientists were held, and an online data collection survey conducted, with additional email requests to collect information on unpublished social science research in progress, with future social science needs, and gaps in the grassland management decision-making literature. For the literature review, both English and Spanish language results were included in the analysis without any restriction on dates of publication. Articles, reports and theses were selected for inclusion and for a more in-depth review if they presented social science data related to grassland stewardship or management decision-making within the Central Grasslands Region.

To ensure the comprehensiveness of this search and increase the number of reports and gray literature in review, literature suggestions were also solicited from social scientists and other

conservation professionals who work in the Central Grasslands. These results were included if relevant. The research team also collaborated with the North Central Climate Adaptation Science Center (housed at the University of Colorado-Boulder) to share relevant literature among complementary literature reviews, as they were also conducting a similar social science literature review concurrently with this one. All metadata were compiled in a spreadsheet and coded for themes around the following topics: types of management behaviors conducted to support grassland conservation, variables that predict grassland conservation behaviors, barriers toward grassland conservation actions, theoretical frameworks applied across the literature, and current social science research and needs.

This approach found 104 papers deemed appropriate for inclusion, given the aforementioned search strategy. The compilation primarily consisted of peer-reviewed articles (n=88), along with eight technical reports and eight graduate theses. Most papers focused on case studies exclusively within the United States (n=91), followed by Canada (n=7), Mexico (n=2), or some combination of two or more countries (n=4). The findings were heavily skewed toward research that studied the decisions of white land managers and land stewards in the United States. To account for this bias, other ways of understanding grassland stewardship were briefly explored, such as Indigenous ways of knowing, community and participatory approaches, and methods from anthropology and sociology that focus on populations other than white ranchers.

> ***Grassland Management Actions:*** Prescribed burning was the most studied grassland conservation behavior and seemed to be over-represented in the social science literature. Papers on burning were followed in frequency by studies focused on voluntary grassland conservation assistance programs, grazing or haying that supports grassland conservation, invasive plant management, grassland restoration, and general rangeland management, such as reducing stocking rates as a conservation practice.
>
> ***Predictors of Conservation Behavior*:** Positive attitudes towards specific grassland management behaviors and a sense of moral responsibility to conserve grasslands were associated with increased willingness to engage in conservation activities. Personal and social norms, along with positive prior management experience, were also found to play a key role in influencing individuals' conservation actions. This suggests that leveraging

moral responsibility and influential social groups could help to engage more land managers in landscape-scale initiatives.

Barriers to Conservation Actions: Major constraints to grassland conservation include a perceived lack of ability, time, and money to conduct specific conservation actions; concerns regarding safety and weather related to prescribed burning; and complexity, bureaucracy, and perceived program inflexibility in relation to voluntary grassland conservation assistance programs. Understanding these barriers to grassland conservation could improve assistance programs or other conservation efforts, perhaps by reducing program complexity and increasing flexibility of participation requirements. Conservation delivery professionals can work to alleviate some of these barriers through landowner outreach campaigns and technical assistance that focuses on the most appropriate management techniques, given landowners' specific needs, and providing resources and training that will increase confidence and connect landowners to monetary and labor resources, where needed (e.g., availability of contractors to help conduct grassland conservation actions and possibilities for cost-sharing).

Other Ways of Understanding Grassland Management: Incorporating diverse social science inquiries, such as knowledge gained through participatory or community-based approaches or disciplines like anthropology and sociology, can enhance conservation strategies by addressing community dynamics and marginalized voices. Indigenous Knowledge Systems might offer valuable insights into sustainable grassland conservation practices, emphasizing the importance of co-producing conservation solutions with these specific communities. Conservation of the Central Grasslands will be impossible in many places without empowered Indigenous nations and communities, with their knowledge of land and water stewardship. The use of Indigenous and Western science together can yield more comprehensive information about grassland stewardship and elevate the importance of grasslands to the livelihoods of human communities across the region. A thorough review of Indigenous literature was not possible across the Central Grasslands, given that there are dozens of Nations. Also, this information may not exist in a written, or other accessible format.

Current Research: Discussions with grassland social scientists touched on current research projects related to evaluating new grassland conservation programs (including payment for ecosystem services approaches), identifying barriers and benefits to conducting specific grassland management practices such as using ranch management plans, determining the perceptions of and factors that predict regenerative grazing, environmental grassland stewardship and grassland conservation program participation, and understanding perceptions of new technologies such as solar energy and how these new technologies might affect grassland management.

The themes found within this review can be incorporated into outreach programming, conservation delivery, and real-world grassland conservation strategies, as described above, yet these studies primarily fall within the realm of social psychology and mainly focus on the needs and decisions of white, male, English-speaking cattle producers and land managers. While grassland conservation professionals still need to work within the dominant grassland conservation framework to a certain extent, this research largely omits the experiences of other populations within this landscape, including historically and currently marginalized populations. The research team that conducted this review works for a US-based bird habitat conservation organization and struggled to find an adequate number of papers related to Indigenous management, Mexican producers, Canadian producers and non-white producers due to limitations in the research and data gathering approach, scarcity of research on these populations, and availability of this research online. Other literature reviews have arrived at similar conclusions, pointing to the need for a deeper understanding of Indigenous worldviews, as well as non-white, female and other perspectives.

Past and current social science research largely reflects traditional landowner perspectives and the mainstream conservation delivery paradigm of working with private landowners to conduct grassland conservation behaviors, often neglecting Indigenous and other diverse voices. Future applied research should prioritize inclusivity and community-led frameworks to effectively address conservation challenges and understand the diverse social and cultural backgrounds of populations and communities who rely on the Central Grasslands. However, these participatory and community-based approaches often require more time and effort to conduct and require building trust with communities.

By applying the insights found in this review, grassland conservation practitioners can more effectively integrate social science information into their grassland conservation goals and strategies. Fostering transdisciplinary collaboration between grassland social scientists, ecologists, conservation delivery practitioners, and community members can ensure a holistic approach to decision-making while facilitating knowledge exchange between partners. Developing strategies to communicate the findings of social science research related to grassland management is also essential. This can be accomplished using a variety of outreach channels to effectively communicate findings and recommendations, while tailoring messages to different audiences such as conservation delivery practitioners or conservation outreach professionals to ensure broad understanding and support.

3 Social Science Needs of Grassland Conservation Delivery Practitioners

3.1 Purpose

While the country-specific cattle producer surveys gave insights on some of the challenges and opportunities related to grassland conservation from the producer standpoint and the literature review examined current knowledge and future social science needs from the perspective of social scientists, it was also deemed vital to understand the social science needs of grassland conservation delivery practitioners to determine whether a gap exists between these needs and the social science research being conducted. Understanding practitioner perspectives on effective landowner and community engagement strategies and human-related grassland conservation challenges was necessary in order to compile a list of recommendations on effective strategies. Last, in order to create a prioritized list of social science research questions and topics to benefit future grassland conservation delivery, practitioners were asked to rate the importance of various research topics and questions.

This information was gleaned through an iterative, modified Delphi process that involved multiple survey rounds to reach consensus and prioritize the needs of grassland conservation delivery practitioners in relation to their work, with an emphasis on eliciting opinions on engagement strategies that improve conservation delivery, and social science and engagement challenges, opportunities, bottlenecks and questions that they would like to be answered.

3.2 Methods

The Delphi Method was initially developed to incorporate experts into forecasting future events. This approach involves eliciting expert opinion on a research question and uses multiple, iterative surveys to allow experts to reflect on the results of previous surveys and reach collective consensus on a topic (Barrett & Heale, 2020). The iterative, participatory, and reflective nature of the Delphi method makes it possible to adapt it for uses where expert consensus is desired. Another benefit of the Delphi approach is that one can gather further feedback on intriguing responses that are uncovered in subsequent rounds of surveys and collect anonymous feedback from experts over a large geographic region in a virtual setting. A modified Delphi approach was used to arrive iteratively at a prioritized list of social science and engagement needs and opinions about effective landowner and community engagement strategies that benefit grassland conservation.

The group of interest was grassland conservation professionals who work with local communities, landowners, and ejidos within the Central Grasslands Region. Participants were contacted and recruited via email, using such existing networks as the Association of Fish and Wildlife Agency Private Lands Working Group in the United States and contacts in Mexico and Canada. Connections with grassland organizations across the Central Grasslands aided in identifying participants and recommending others through snowball sampling. The initial survey and forwarding request went to 52 practitioners across the Central Grasslands region. These contacts represented a broad geographic coverage (country and state/province), types of practitioners, organizations (state/provincial, tribal, federal, nongovernmental), and stage of career.

This needs assessment also involved iterative surveys via a Google Forms to reach consensus and prioritize the social science needs of practitioners and managers in relation to their work. Opinions on engagement strategies were elicited that could improve conservation delivery and challenges in implementing these engagement strategies. There were English and Spanish language versions of each survey. All prompts and topics were translated to Spanish using Google Translate and proofread by a bilingual speaker.

After the initial elicitation survey, feedback was coded to identify common themes. In the follow-up survey, respondents were asked to rate the list from the initial elicitation survey (round 1) with the goal of generating a prioritized list of research questions for conservation social scientists to work on for future integration into conservation delivery and engagement strategies to improve conservation within the Central Grasslands.

In the initial elicitation round of the survey, respondents were asked four main questions:

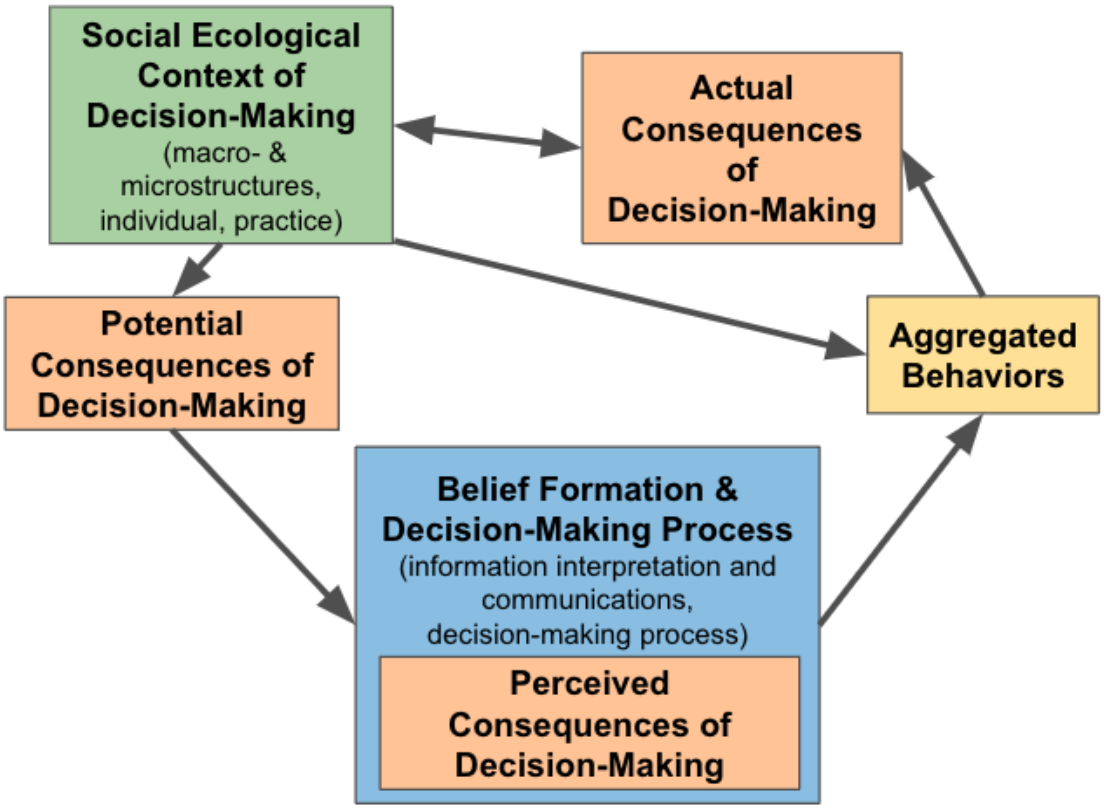
1) From your professional perspective, what are the biggest grassland conservation challenges that relate to humans across the Central Grasslands as a whole?
2) From your professional perspective, what are the biggest grassland conservation challenges that relate to humans where you specifically work (within the Central Grasslands region)?
3) What social science related topics or research questions would help your grassland conservation efforts within the Central Grasslands region?
4) From your perspective, what are the most effective landowner and community engagement strategies to encourage grassland conservation and stewardship where you work in the Central Grasslands region?

Demographic questions were asked to determine the breadth of the responses related to geographic scope (location and scale of work) and practitioner variables (job title, organization of employment, and career stage). To ensure that responses were received from appropriate types of professionals, screening language was included to ensure that only grassland conservation professionals who work with local communities, landowners, and ejidos within the Central Grasslands Region should complete the survey. A map of the Central Grasslands region was included for reference to aid those who might work across states/provinces where only a portion includes the Central Grasslands.

After the first survey, inductive thematic coding was used to categorize responses to the human-related grassland challenge questions and the landowner and community effectiveness questions. Once each response was coded, related responses were grouped into themes and combined where there was significant overlap. Themes were then discussed with the rest of the author team.

The research needs question was coded differently from the other questions using a framework for understanding private land conservation decision-making that was developed by Epanchen-Niell et al. (2022). This framework (Figure 2) was selected as a basis for coding because it had been derived using a combination of literature and research across three broad social science disciplinary emphases: economics, psychology and sociology.

Figure 2. Simplified diagram of landowner conservation decision-making used for analysis of research needs



Source: Adapted from Epanchin-Niell et al. (2022)

The framework outlines different categories and subcategories of variables and how they are related to conservation decision-making. These categories are broadly related to the social ecological decision-making context, consequences of decision-making, aggregated behaviors, and belief formation and the decision-making process. Social ecological decision-making context relates to the structures and characteristics across scales (macro-, micro-, individual and practice)

within which decision-making occurs. Within this category, subcategories include macrostructures which relate to the broad scale political, institutional and societal factors that can affect decisions. Microstructures are those related to households, communities and social groups. The individual sub-category includes the characteristics of the decision maker including their values, identity, and demographics, among others. The practice sub-category includes factors related to a given practice such as trialability, relative advantage, complexity, among others. The consequences of decision-making categories of variables relate to the potential and actual social, economic and ecological outcomes of a given decision. For this analysis, consequences were treated as one category rather than being parsed into potential, perceived and actual categories, as indicated by the diagram. Aggregated behaviors are the cumulative behaviors across decision makers. For the analysis, the belief formation and the decision-making process category is composed of the subcategories: information interpretation and communications, and the decision-making process. As mentioned above the perceived consequences of decision-making were grouped in consequences of management

The coding thus created a structure that grounded the research topic responses in pre-existing research approaches for understanding landowner decision-making and so provided a useful tool for translation of the applied research questions to more general research foci and literature, while also enabling assessments where the prioritized needs gathered in the Delphi process fall within a comprehensive behavior model. This model does not expressly account for all forms of grassland management decision-making, such as communal or Indigenous land management scenarios. However, overall, these categories fit within the broad coding structure that was adapted from the decision-making framework to iteratively code the responses. First, research topics and questions were assigned to the broad main categories (e.g., social ecological context of decision-making). Once these general categories were assigned, the questions or topics were further coded to the specific subcategories (e.g., “macrostructure”). Once each response was coded, they were grouped with related responses and combined with them where a significant overlap was suggested.

The second survey was sent only to those who completed the initial survey, and it asked respondents to rate the importance of social science questions and topics and effectiveness of landowner and community engagement strategies given as responses to the first survey. It also asked about barriers to implementing the engagement strategies and provided respondents with

an opportunity to give any additional feedback on the research or engagement topics to incorporate in future surveys, which is a hallmark of the Delphi process. In order to reduce the number of responses included in the second survey for the social science research needs, the questions centered on topics that were not specifically related to social science (e.g., habitat use of deer) were removed. Although these topics impact decision-making, they fell outside the scope of this review's research needs.

The remaining responses were parsed into discrete topics, rephrased as general research actions (e.g., understanding the goals of landowners) and edited for clarity. Throughout, this process erred on the side of including topics and made minimal edits to keep nuances that were provided by the respondents. Each research action was then provided in question blocks that roughly approximated the coding structure: understanding landowners and their social-ecological environment, understanding management outcomes, understanding communications, knowledge and decision-making, and understanding group behavior. Respondents were asked their thoughts on the importance of each social science research topic or question using a unipolar, five-point importance scale ("not at all important" to "extremely important"). Given the breadth of grassland conservation practitioners from whom information had been solicited, a "Not Applicable" indication was marked so that only those topics that pertained to their expertise would be rated.

For the landowner and community engagement strategies, respondents were asked to rate the effectiveness of each engagement strategy theme or category on a unipolar, 5-point effectiveness scale ("not at all effective" to "extremely effective").

Specific question wording for the second survey can be found below:

1) Please indicate how important you think the following social science research topics or questions are to informing your grassland conservation efforts within the Central Grasslands Region.
2) Please indicate how effective you think the following categories of landowner engagement strategies are at encouraging grassland conservation and stewardship where you work in the Central Grasslands region. The specific engagement strategies that fall within each category that were mentioned in the first survey are listed below each category.

3) Of the categories of landowner engagement strategies that you rated as most effective above, what are the barriers to implementing that type of strategy?
4) Please indicate how effective you think the following categories of community engagement strategies are at encouraging grassland conservation and stewardship where you work in the Central Grasslands region. The specific engagement strategies that fall within each category that were mentioned in the first survey are listed below each category.
5) Of the categories of community engagement strategies that you rated as most effective above, what are the barriers to implementing that type of strategy?
6) Is there anything else related to social science research needs, landowner engagement strategies, and community engagement strategies that you'd like us to consider?

A meta-analysis of 100 Delphi studies found a range of 50-97% for consensus with a median of 75% (Diamond et al. 2014). A minimum consensus threshold of 70% of respondents was used, sufficient to indicate that the topic was very or extremely important. This helped to create lists that erred on being more inclusive and less prone to biases from the potential unequal distribution of respondents across geography, career stage, and scope of work that may have resulted from the snowball sampling approach.

During the third survey, respondents to the previous two surveys were asked to provide feedback for prioritizing research topics. Respondents were provided with an array of the research questions within each category that had been agreed upon as being particularly important, for which they were asked to rate the top three research topics. Due to the number of responses in the social and ecological context of the decision-making category, this was broken out into the two question blocks that included the micro- and macrostructures and individual and practice subcategories, respectively. Participants were also asked to provide any additional feedback that they had for the list of social science research topics. A prioritized list of research topics was created by assigning a score to each importance ranking (e.g., most important = 3, 3rd most important = 1), summing the scores for each item and then ordering them by their scores.

In the third survey, respondents were also asked to rate the importance of specific engagement strategies that occurred within the engagement categories that had been agreed upon in the

second survey. Further, respondents were asked to comment on the importance of landowner and community engagement topics that had reached consensus, to provide comments on the ambivalent responses that had been given, in relation to the use of a financial incentive engagement strategy.

Specific question wording for the third survey can be found below:

1) Please read the list of important social science research questions/topics within the following categories (rated in survey 2) and select the top three most important topics within each category for informing grassland conservation efforts within the Central Grasslands Region.
2) Are there suggestions or additional information that you would like to provide related to the following categories of social science research topics?
3) What are your thoughts related to the landowner and community engagement categories (asked separately) reaching consensus related to effectiveness?
4) How effective do you think the following engagement strategies are at encouraging grassland conservation and stewardship where you work in the Central Grasslands region?
5) While the using financial incentives category reached consensus related to effectiveness, many also indicated that lasting grassland conservation engagement strategies must go beyond simply paying people to conduct grassland behaviors because financial incentives may not be sustainable in the long term or lead to the development of an individual or community grassland conservation ethic (which was seen as important for lasting conservation of the Central Grasslands). Do you have any thoughts you'd like to share on this issue?
6) Is there anything else about social science needs and engagement strategies related to grassland conservation or this project in general that you'd like us to consider?

3.3 Results

Seventy-eight responses were received to the initial elicitation survey. These respondents covered the entire Central Grasslands region, with at least one respondent who worked in every state, province, and country that makes up the region. Most respondents' scope of work covered a portion of a state/province (47%; n=37), with 28% (n=22) covering an entire single

state/province, 17% (n=13) covering multiple states/provinces, 5% (n=4) working at the national level (country or Indigenous Nation), and 3% (n=2) working tri-nationally. Most worked within the United States (n=62), while 14 worked in Mexico, 7 worked in Canada, and 6 respondents worked within Indigenous Nations. These responses were not mutually exclusive, with some respondents working across multiple nations. Organizations that respondents worked for included nongovernmental organizations (45%; n=35), state/provincial agencies (31%; n=24), federal agencies (18%; n=14), and other types of organizations, such as independent consultants and ranchers who work with other ranchers (6%; n=5). Last, a good range of career stages were represented in respondents, with 38% identifying as early in their career (n=30), 41% identifying as mid-career (n=32), and 21% identifying as late career (n=21). Fifty-eight (58) responses were received to the second survey that was sent out to those who completed the first survey, for a 74% response rate from round 1 to 2. Thirty-six (36) responses were received for the third survey, yielding a 62% response rate from round 2 to 3.

3.3.1 Human-related Grassland Challenges

Although separate questions were asked pertaining to the biggest grassland conservation challenges that affect the Central Grasslands region as a whole and, more specifically, where each respondent worked (within the Central Grasslands), many respondents gave similar responses to both questions, thus the same themes came up for both questions. Some respondents focused on the actual causes of grassland loss as the challenge, mentioning exurban and urban development, habitat fragmentation, crop conversion, woody plant encroachment, invasive species, poor grazing management, and aerial spraying of forbs.

An important challenge pertained to government policies, and many mentioned that agricultural and insurance policies have made it more financially lucrative to grow crops (i.e., to convert grasslands to cropland), thus putting financial pressure on those who manage grasslands to convert to crops. Others mentioned that economic and governance factors don't consistently support or incentivize grasslands, in general, especially in priority conservation areas. Somewhat related to policies, as policies often dictate economics, was an economic theme with respondents mentioning cost barriers to restore native grasslands or maintain existing grasslands through fire, grazing, or other invasive species removal methods. They also mentioned that land valuation metrics make cropland more valuable than grasslands and crop prices being at all-time highs, making it difficult for grassland agricultural producers to stay in business.

Still others mentioned communication with a lack of consistent messaging from conservation organizations related to grassland conservation made it confusing to follow best practices and stay coordinated. There were also quite a few challenges mentioned that related to (human) management perceptions, such as the difficulty of changing practices that have been passed down over generations, even if they are detrimental to grasslands. Also mentioned within this theme was the perception that managing native grasslands is burdensome, due to the presence of threatened or endangered wildlife species (according to different jurisdictions) or due to ecological changes such as drought and flooding. Respondents mentioned a general lack of fire culture and varying land objectives of neighbors or across regions, making it difficult to work together on shared grasslands goals. Lastly, respondents mentioned that producers making decisions to prioritize short-term financial gains or perceiving a lack of economic benefits of maintaining native grasslands were also perception-related challenges to grassland conservation.

Respondents also mentioned various challenges relating to a general lack of public knowledge or awareness about grassland conservation issues. This included lack of public awareness about the plight of the Central Grasslands region and risks of grassland loss, lack of knowledge of the ecological goods and services that healthy grasslands provide, and overall public disconnect from the outdoors. It also included lack of producer awareness of the proper grassland management techniques to use and the inability of conservation delivery professionals to understand the diversity of people who are necessary to conserve grasslands and how different cultural backgrounds influences decision-making. In other words, a lack of social science knowledge among conservation delivery professionals was seen as a barrier to grassland conservation.

Respondents also noted that changing values across the region challenged grassland conservation. This included people valuing trees over grasslands, shifts to larger scale agriculture and more corporate agricultural land ownership that may put short-term profits first and thus favor cropped systems. Frequent changes in land ownership and a new generation of landowners who don't have grassland or land management experience were also mentioned as challenges. Issues related to difficulty in managing complex grasslands due to larger operations or the need to balance food production and grassland management also reflect some of the challenges that come with changing values and society. Human demographic shifts were also mentioned as grassland conservation challenges, but in different ways. This included respondents mentioning a loss of human population from rural areas and a simultaneous exurban migration which favors

smaller, more fragmented land parcel sizes. The growing global population that must be fed by the agricultural sector was also mentioned, which may put more grazing pressure or crop conversion pressure on the grassland systems.

There were also barriers that are difficult to categorize, such as the comment that not all interested and important groups often get engaged in grassland conservation efforts. The various issues listed also point to many opportunities to fix those challenges through strategies that effectively engage both landowners and communities around grassland conservation.

3.3.2 Effective Landowner and Community Engagement Strategies

To understand the most effective landowner and community engagement strategies, grassland conservation practitioners were asked to list the strategies that they perceive as most effective from the first survey. For landowner engagement, seven major categories of engagement strategy were identified and three were uncategorized:

- **General Education and Outreach** with the hopes that these strategies will eventually lead to grassland conservation behaviors.
- **Targeted conservation delivery practitioner strategies** (both in hiring practitioners and strategies that the practitioners should use) to build trust, form relationships, and support landowners with grassland conservation behaviors.
- **Landowner-led or peer-to-peer programming** where landowners or producers can learn from each other about grassland conservation strategies.
- **Conservation practice demonstrations** so that producers can see the effects of conservation strategies in action and learn about how to conduct the strategies firsthand.
- **Holistic conferences and trainings** that include various aspects of cattle producer livelihoods in addition to grassland conservation practices.
- **Promoting membership in groups that focus on grassland and rangeland issues** such as livestock, grazing, and prescribed burn organizations.
- **Using financial incentives** to facilitate engagement by providing financial incentives or cost share for grassland conservation behaviors.
- **Other**
    - **Policy protections** to facilitate engagement that ensure landowners are protected from future regulatory actions if they voluntarily participate in grassland conservation and stewardship.

- **Acknowledging the work that ranchers have done for generations** to encourage continued stewardship.
- **No single strategy is most effective across the entire landscape.** This work depends on the context, the types of people involved, and their histories of participation in grassland management.

For community engagement, similar strategies to those mentioned above were also included, with the exception of holistic conferences and training, policy protections, and landowner-led or peer-to-peer programming. The following two additional categories and one uncategorized strategy was also mentioned:

- **Coordination of education and outreach.**
- **Supporting community-led grassland conservation efforts.**
- **Formation of multi-sector alliances** that operate in a horizontal (collaborative) and participatory manner.

In the second survey, respondents were asked to rate the effectiveness of each of these categories of landowner and community engagement strategies (separately). The actual strategies that were mentioned within that category in the first survey were also listed in each question with minimal editing so that respondents could use this information when making their rating decisions. Using the 70% threshold of effectiveness (combining very and extremely effective ratings) to indicate consensus, consensus was received on three categories of landowner engagement strategy: targeted conservation delivery practitioner strategies (86%), landowner-led or peer-to-peer conservation programming (72%), and using financial incentives (74%) (Table 1).

Table 1. Landowner engagement strategy effectiveness rating percentages ("very" and "extremely" effective) by category

Category	**Effectiveness Percentage** ("very" and "extremely")
Targeted conservation delivery practitioner strategies.	**86%**
Using financial incentives.	**74%**
Landowner-led or peer-to-peer programming.	**72%**
Acknowledging the work that ranchers have done for generations.	52%
Conservation practice demonstrations.	48%
Policy protections.	47%
Promoting membership in groups that focus on grassland and rangeland issues.	33%
Holistic conferences and trainings.	31%
General Education and Outreach.	29%
No single strategy is most effective across the entire landscape.	28%

Note: Items in **bold** indicate consensus on a particular category.

For community engagement strategies, no consensus was reached in any category of engagement (Table 2). The following quote aptly demonstrates this:

> "each area has no single perfect catchall, so the biggest barrier to implementing any strategy is that there is no perfect strategy. What these all touch on is trying to essentially influence rural community dynamics, something that has been shaped over hundreds of years, and that may take just as long to be reshaped. The people who exist in these communities are the ones who have succeeded for generations, so to say that their methods are no longer working is counter intuitive. Thus, it is when landowners come to the conclusion themselves that what they are doing is no longer working is when the conservation delivery specialists gain an opportunity to insert themselves and provide a resolution that works for both people and the environment. As these pressures grow, be it climate change or woody encroachment or other, the developing slow pace of these

issues is both the biggest barrier and greatest asset to trying to engage communities on these very topics."

Respondents were also asked to comment specifically on the fact that no community engagement strategy had reached consensus in the third survey. As mentioned above, many said that community engagement strategies must be locally focused and that no one strategy will work for every community. Respondents also mentioned that because each community is different, so is success and that success of specific strategies and initiatives often goes unmeasured. Others mentioned that community engagement must start at the individual level and that there was no consensus on effective strategies, likely because community engagement is so difficult or because professionals have low confidence about the organization of these strategies in local communities.

Table 2. Community engagement strategy effectiveness rating percentages ("very" and "extremely" effective) by category

Category	**Effectiveness Percentage** ("very" and "extremely")
Targeted conservation delivery practitioner strategies.	64%
Supporting community-led grassland conservation efforts.	57%
Conservation practice demonstrations.	55%
Acknowledging the work that ranchers have done for generations.	47%
Using financial incentives.	45%
Coordination of education and outreach.	38%
Formation of multi-sector alliances.	36%
General education and outreach.	29%
Promoting membership in groups that focus on grassland and rangeland issues.	29%
No single strategy is most effective across the entire landscape.	28%

Specific landowner and community engagement categories elicited in survey 1 were very similar across categories (see Appendix 1 for full list of listed strategies). The specific landowner engagement strategies described earlier had categories for respondents to indicate consensus on ratings of effectiveness. The targeted conservation delivery practitioner category included both hiring and recruitment of grassland conservation delivery professionals and strategies for working with landowners. Listed strategies focused on the recruitment and retention of conservation delivery professionals by embedding these positions within local communities and hiring practitioners who are experienced with grassland conservation practices and can speak from experience. Within this category, the actual conservation delivery strategies included developing long-term relationships through one-on-one conversations with producers, having an ability to be patient when discussing different grassland conservation programs or practices, listening more than talking, and taking the time to understand local cultures.

In the landowner-led or peer-to-peer conservation programming category, programs where producers can see the benefits of grassland management and learn from other producers were mentioned. Encouraging and supporting local leaders in becoming conservation champions or encouraging producers to tell other landowners about the benefits of conducting grassland conservation behaviors was also mentioned. The use of financial incentives category mainly involved financially incentivizing different grassland conservation behaviors such as providing cost-share opportunities for grazing infrastructure and promoting grassland easement that provide economic benefits to producers. Keeping reimbursement processes simple for producers was also mentioned as an effective strategy.

In the third survey round, respondents were asked to rate the effectiveness of the specific engagement strategies mentioned earlier, that fell within the three agreed-upon categories of landowner engagement strategies in survey 2. Of these specific strategies, many received consensus ratings on effectiveness with 9/13 targeted conservation delivery practitioner strategies, 2/4 landowner-led and peer-to-peer strategies, and 2/4 using financial incentives strategies reaching agreement on effectiveness (see Table 3 for a complete list of strategies and effectiveness rating percentages).

Table 3. Specific landowner engagement strategies that achieved consensus within broader engagement categories that also received consensus and effectiveness rating percentages ("very" and "extremely" effective)

Category	Specific Strategy	Effectiveness Percentage
Targeted conservation delivery practitioner strategies	Forming strong, long-term relationships with landowners.	97%
	Starting long-term relationships through voluntary conservation program conversations.	78%
	One-on-one, in-person communication between practitioners and landowners.	94%
	Listening to producers' needs and understanding how to make connections between conservation practices and landowner management objectives.	94%
	Listening more than talking.	78%
	Placing long-term biologist positions embedded in local communities and invest in those positions so they have long-term tenure.	83%
	Hiring practitioners who are experienced with on-the-ground grassland conservation practices and can help with the work.	75%
	Practitioners being able to speak from actual experience of doing the work (burning, cutting trees, etc.).	86%
	Bringing additional resources (professional help or money) to improve/maintain existing management regimes.	77%
Landowner-led and Peer-to-Peer Programming	Peer-to-peer groups where producers can see the benefits of grassland management behaviors from other producers.	77%
	Encouraging landowners to tell other landowners about the benefits they've experienced from conducting grassland conservation behaviors (word of mouth).	86%
Using Financial Incentives	Providing cost-share opportunities for cattle grazing infrastructure and payments for grassland conservation actions.	78%
	Keeping reimbursement for conservation practice processes simple.	89%

3.3.3 Social Science Research Needs

The first round of social science research needs yielded topics from each of the main decision-making categories. Submitted statements varied by the topic area that they indicated were areas for research. When organized into non-exclusive categories, the area most referenced was social ecological context of decision-making (n = 48), followed by belief formation and decision-making process (n = 37), consequences of decision-making (n = 34), and aggregated behaviors (n = 8). After consolidation and cleaning of responses, 78 topics were included for importance scoring in the second round of the Delphi survey (see Appendix *2* for the full list of topics).

During the second round of responses, an average of 49 responses were received for each of the topics (excluding topics that weren't applicable to respondents). Of the original 78 topics that respondents were asked to identify as important, 39 items met the 70% consensus criteria ("very" or "extremely important") for inclusion in the social science research topics. These responses were not evenly distributed across the different categories, except for the aggregated behaviors category, for which no topics were identified as important.

The social and ecological context of decision-making contained the most topics that were agreed upon (Tables 4, 5). A total of 26 items were agreed upon as being important for this category, with eight in the macro- and microstructure subcategories and 18 in the individual and practice sub-categories. These topics thus covered multiple scales of the social and ecological context of decision-making and were ranked separately.

Among the macro- and microstructure subcategories, the top three ranked items had significantly higher-ranking scores than the remaining items (Table 4). These items included topics related to understanding grassland conservation policies and programs and their impacts on economics of production and conversion of grasslands to cropland via understanding the role of incentives, subsidies, insurance and ecosystem service-based approaches on grasslands. Microstructure related topics were centered on gaining a better understanding of the way that conservation professionals develop relationships with landowners and how landowners would like to be engaged by conservation delivery professionals.

Social science research topics within the individuals and practice subcategories were the most numerous items that were agreed upon by conservation delivery practitioners (Table 5). The five highest ranked items had much higher-ranking scores than the remaining items. These topics

included understanding landowners' values and motivations related to grasslands and their management decisions. Topics also included gaining a better understanding of ways to achieve grassland conservation behavior change and the role that economics plays in this and examining the barriers of and economics related to adopting different practices such as controlling woody plants, using prescribed fire and implementing grazing plans.

Conservation delivery professionals also provided open-ended feedback related to the social and ecological context of decision-making category as part of the third round of surveys (Appendix 3). This feedback included opinions on additional practices to be studied ("values and attitudes about pastoralism"), opinions on research topics, "barriers to conservation generally is more important than specific types of conservation practices", and deeper perspectives on the consensus topics:

> "The willing to pay question […] could be looked at from four perspectives: what are landowners willing to pay, what is the public willing to accept in terms of grassland quality, and then what is the public willing to pay for grassland quality, and what are landowners willing to accept to implement conservation on their lands […] we need to see how these expectations align or differ. Because for all we know, despite EQIP already being a massive program, maybe the public is willing to pay even MORE if it means ensuring the protection of this critical resource."

Table 4. Ranked order of key social science research topics related to the macrostructure and microstructure subcategories within the social and ecological context of decision-making category

Topic	Rank	Score
Examining what happens to the economics of grassland conversion to other land use types when federal insurances and subsidies are removed.	1	39
Determining the critical steps that conservation delivery specialists are missing when developing relationships with landowners that are hesitant to work with agencies on grassland improvements.	2	37
Determining how to develop voluntary grassland conservation programs that increase the value of land based on multiple factors such as net productivity, and environmental or recreational services.	3	36

Understanding public perceptions of healthy grasslands, cattle production, and threats to grasslands (such as woody plant encroachment) versus their perceptions of these factors in other ecosystems.	4	28
Determining what factors are necessary to conserve grasslands in agriculturally dominated regions.	5	23
Determining the strength of economic factors pushing people to convert grasslands to other land use types.	6	22
Determining what changes to the landowner socio-political environment are necessary for positive grassland change.	7	20
Determining the level of involvement or follow-up that is desired by landowners and managers when participating in voluntary grassland conservation incentive programs.	8	11

Table 5. Ranked order of key social science research topics related to the individual and practice subcategories within the social and ecological context of decision-making category

Topic	Rank	Score
Understanding agricultural producers' perceptions of grassland versus cropland profitability, including when federal insurance and subsidies are removed.	1	32
Determining what it would take to convince landowners to implement grassland restoration and conservation practices on their properties instead of other land uses.	2	29
Understanding landowners' motivations for restoring or destroying grasslands and how money factors into this.	3	22
Determining the barriers to implementing conservation practices and supports that would help landowners overcome those barriers.	3	22
Determining the profitability in operations that seek to restore grassland health, rather than just producing beef or a crop.	5	19
Examining the relative economics of different grassland conservation practices and if and how these economic factors help stop the breaking of native sod and increase lands enrolled in conservation programs (e.g., Conservation Reserve Program grasslands) from being converted to crops.	6	16
Determining how to convince inherited landowners to change generational practices and try new practices.	7	11

Understanding whether landowners recognize the value, threats and loss of grasslands.	8	10
Determining what landowners are willing to pay for conservation practices that would benefit grasslands.	8	10
Determining how conservation professionals can create more internal motivation in landowners to address grassland issues.	8	10
Determining how to increase agricultural producer acceptance of grassland conservation.	8	10
Determining the barriers keeping people from managing their grasslands long-term.	12	9
Understanding individual motivations to participate in voluntary grassland conservation incentive programs.	13	6
Determining the barriers to implementing prescribed grazing plans.	14	5
Understanding key non-financial motivations for protecting grasslands.	15	3
Understanding the factors that determine why some landowners do not control woody tree encroachment on their grasslands such as lack of time, manpower, financial, etc.	16	2
Understanding livestock producers' willingness to change management and why some are reluctant to use certain practices (e.g., fire, herbicide).	17	0
Determining the barriers to adopting fire or using herbicides on grazing lands.	17	0

Note: Topics with the same rank had an equal ranking score.

Within the topics agreed upon as important related to belief formation and the decision-making process category, some were related to information interpretation and communications while others related to the decision-making process (Table 6). The information interpretation and communications topics included identifying information that is needed to get the public or landowners to value grasslands and how to develop effective communication materials. Regarding the decision-making process subcategory, important topics included understanding how landowners plan and weigh different options when making their decisions and the time frame within which these decisions occur and how to maintain the persistence of conservation behaviors after programs end.

The top three items in the prioritized list of the belief formation and decision-making process category were substantially higher than the remaining items. These highest scoring items included topics that related to understanding how to help landowners achieve a sustainable balance in their production systems, followed by understanding persistence of behavior and landownership. Although not included in the third round of the survey (and so not ranked), based upon the responses to the second round of the survey, it is anticipated that these information interpretation and communication-focused topics would have ranked highly and just below these topics (Table 6).

Feedback related to the belief formation and decision-making process category (Appendix 3) suggested that studies to understand decision-making related to "transgenerational division of land" and income for families and their willingness to pay versus acceptance for grassland conservation were also important.

Table 6. Ranked order of key social science research topics related to the belief formation and decision-making process category

Topic	Rank	Score
Determining how landowners can best achieve a balance between conservation, management and production.	1	45
Understanding post-grassland management practice behavior to support grassland persistence and how to bridge the gap between different voluntary grassland conservation programs or help landowners plan for the future once income from incentive payments end.	1	45
Understanding how to promote grassland landownership and management persistence to reduce the churn rate of grasslands that are converted to other land uses and keep large grassland blocks together.	3	41
Determining the planning steps that landowners take when deciding to convert native grasslands to another land use type and what role financial factors play in this decision process.	4	30
Determining what information would help people acknowledge that grasslands are a valuable natural resource.	5	25
Determining the barriers that keep people from managing their grasslands long-term.	5	25

Determining the outcomes a grasslands manager needs to show to receive economic benefits that are supported by the public (e.g. biodiversity benefits, lost economic opportunity, costs to manage, simple presence/absence of grasslands).	NR	NR
Determining ways to develop effective extension programs, environmental education, technical advice, and stewardship materials for new landowners.	NR	NR

Note: Topics with the same rank had an equal ranking score, those with "NR" were not ranked.

Within the agreed upon important social science topics related to the consequences of management category, most items were associated with the outcomes of a given practice (Table 7). The management practices discussed included ones that both positively and negatively affected grasslands. The outcomes that were most often agreed upon related to the costs and benefits of practices such as prescribed fire, grassland conversion to crops, and agricultural production on native grassland. Outcome topics also included collection of information to translate the outcomes of conservation work for communication to the general public to increase understanding and support for conservation efforts. These two highest scoring items had significantly higher-ranking scores than the remaining items.

The consequences of decision-making category received the most feedback from respondents (Appendix 3). Respondents suggested new research topics such as understanding "historical changes in grassland condition" and the "role of community management." They also commented on the need to increase the geographic focus of research topics (e.g., regional or landscapes) and also broadening the topical focus ("cost of annual crop agriculture […] in regard to healthcare, Medicaid, and food prices"). Application of the research was also commented on ("being able to explain what parts of a ranching operation are benefited by what conservation program").

Table 7. Ranked order of key social science research topics related to the consequences of management category.

Topic	Rank	Score
Collecting economic data that demonstrates grassland agriculture sustainability including the environmental benefits of well managed grasslands, and their measurable economic impacts (carbon storage, water and nutrient cycle restoration, wildlife habitats).	1	47
Determining the size of incentives or payments for ecological goods and services that are required to meaningfully reverse the current loss of grasslands and wildlife habitat within it.	2	43

Quantifying the goods and services that grasslands provide and how they contribute to quality of life.	3	27
Improving understanding of the economics of production (livestock production, hay production, seed production, etc.) on perennial grasslands.	4	23
Improving understanding of the profitability of grasslands.	5	21
Identifying ways to empower the general public to conserve grasslands.	5	21
Understanding the economic impacts of overgrazing or the conversion of native prairie.	7	18
Quantifying the positive impacts of conservation work being done on grasslands and how these are being interpreted by the general public within a region.	8	12
Understanding the costs, benefits and risks of prescribed fire.	9	4

Note: Topics with the same rank had an equal ranking score.

3.3.4 Landowner and Community Engagement Barriers and Opportunities

The general barriers to implementing landowner engagement strategies that were unassigned to a category also included:

- Lack of time, money, and capacity to conduct conservation delivery activities.
- Lack of political will (to focus on these type of engagement events).
- Lack of community organization (to conduct conservation delivery).
- Lack of any monitoring by FSA/NRCS in any grassland programs (with the thought that people continue to be paid for poor management).
- Continuing negative political propaganda related to working with wildlife.
- Landowners not wanting government interference in their business.
- Complexity and fluidity of grassland conservation.
- Agency and institutional support.
- Shifting and changing farmer attitudes.

Many of the barriers for community engagement that respondents listed were similar to the ones listed above for landowner engagement strategies, with some important nuances. Unassigned barriers included:

- Time, money, conservation staff capacity, and labor to conduct the conservation practices.

- Agency and institutional support.
- Lack of a cohesive and comprehensive engagement strategy across the region.
- Disintegration of agricultural communities, making it difficult to conduct engagement.
- Prevailing sentiment that working with the government is a bad idea for producers.
- Landowners not wanting to be told what to do with their land by non-ranchers.
- View engagement as something that must truly be about cooperation and not just conservation organizations trying to get communities to do what gets a little better.
- Government uncertainty (to support programs).
- General negative social and political attitudes towards people within rural areas (specifically mentioned in a Mexico context).

Related to the landowner engagement categories that were agreed upon as effective, respondents mentioned that biologist time and lack of capacity were big barriers to implementing targeted conservation delivery practitioner strategies. There were also many barriers mentioned related to the recruitment and retention of conservation staff. These included a difficulty in getting conservation delivery staff to stay rooted in rural communities. Many positions are entry-level, with low salary, and staff have no previous connection to the community. Trust and relationships were mentioned as essential to effectively delivering conservation, but trust and relationship-building takes time, which can't happen when conservation delivery staff turnover is high. It was also mentioned that the skills and abilities that supervisors use to choose conservation delivery staff might not be the best in employee retention. If conservation delivery employees are chosen based solely on their skills and experience in wildlife conservation, they might not understand agricultural environments or be good listeners or communicators, making it difficult to connect to producers. Also mentioned was the disconnect between the effective conservation delivery strategies that involve building trust and the annual evaluation metrics that conservation organizations and grants use to evaluate success, which are often acres on the ground. For example, if a high-quality conservation project on private lands takes five years to achieve, an employee might not look like they've done much on an annual basis.

The following quote sums up these issues very well:

> "Delivery Practitioner - you hit on some big ones. Pay is the most obvious. We need to pay people enough so that they don't grab the first job they see elsewhere. And we need to stop thinking of these delivery jobs as entry level. If we truly value the resource and

> want to invest in its future, we need to up our pay and expertise. Also, we have to stop putting people out on islands. The next generation is younger and more urban. They may love wildlife and grassland, but they may have no idea about rural living, and so throwing them out into some random Central Plains grassland community is tough. We need better support systems, more communication, better integration with local teams and communities. How can we support those people, personally and professionally, from Day 1. Relationship development with landowners takes time, years, and turnover is a killer for conservation - both in terms of the actual grasslands and landowner relationships. It becomes the boy who cried "conservation." The more biologists they encounter who leave, the less likely they are to engage down the road. And the less experienced they are, the harder it is to create that trust and buy-in. I wish it weren't true, but it is. Not to say young, inexperienced can't be successful, but it's definitely more difficult. In this sense, better pre-deployment training is needed from agencies, universities, professional societies, and others. Training in both on-the-ground delivery and communication. Finally, why do these local folks have to be professionals? There are several examples of local community leaders stepping up to fill this role - it's not a wholesale solution, but it would expand our capacity. Find a local agricultural leader, cultivate that relationship, have them deliver the message. Take the help where we can get it and find ways to support these individuals."

Related to landowner-led programming, respondents mentioned that it was often difficult for conservation delivery professionals to identify conservation champions within the community due to time and capacity constraints and the staff turnover issues mentioned previously. Additionally, these landowner champions might not have the communications skills necessary to promote actions or have the time to plan and speak at programs. They also mentioned that it was generally difficult to recruit landowners to attend trainings because they are often busy, and trainings might not be held at convenient times or in convenient locations. It was also mentioned that many trainings targeted at producers were attended mainly by conservation professionals. Others mentioned it was difficult simply getting conservation information out to landowners in the first place and scaling up engagement strategies to communities that are generally focused on individual landowners.

On the financial side of things, the barriers mentioned were rather diffuse. While some simply mentioned that producers need more money to conduct conservation behaviors, others

mentioned that the power and influence of the crop industry really prevent grassland economic support. People also mentioned that some of the programs that promote grassland conservation, such as the Conservation Reserve Program in the United States, actually make it more profitable to grow crops first. As one respondent said:

> "The financial incentives for grassland conservation are needed, but not as important as fixing a broken incentives system. Producers are rewarded for falling in line with commodity crop production with price and production protections not offered to grassland producers. Couple that with incentives to conserve grassland, such as top dollar CRP/easements, and you have the perfect recipe for producers to not conserve or manage what they have and instead destroy it to be paid to put it back together. Consider this very common scenario. Pasture that rents out for grazing/haying at $60-100/ac. Insurance will only pay $10-50/acre and be more expensive due to lack of federally subsidized crop insurance. A landowner has a better incentive to sod bust, have 5 poor crop years, insured at 50% the federal rate due to sod busting, but then make $300/acre/yr in CRP, and this is essentially a perpetual payment since once in CRP, it can be re-enrolled indefinitely."

According to the aforementioned respondent, these programs to benefit grasslands may actually harm them since breaking out grass to crops in the first place causes damage that may take decades to recover once the land is converted back to grasslands. Another respondent said that money is "one of the least pressing obstacles, but rather knowledge and a motivation to act."

While financial incentives were listed as an effective engagement strategy, this might be due to the current structure of the mainstream conservation delivery paradigm in the United States and Canada, which is set-up to promote financial incentives. Concerns about continuing to promote grassland conservation strategies using financial incentives were brought up in the open-ended question that asked about any other items that respondents wanted considered in survey 2. This can be illustrated in the following response:

> "Much of this survey revolved around incentives and we have to understand that we can't pay our way out of this situation. We must focus on stewardship and changing mindsets which is incredibly difficult and will come from local involvement. Insurance for rangeland would only exacerbate a crop insurance problem that we have in grasslands for grasslands conversion, and we can't go that route. Addressing the subsidy issue that

> encourages poor management would go a long way in conserving grasslands. I'm sure there are other thoughts but those were the ones that stuck out most to me."

To uncover more nuance related to the financial incentives category, in survey 3 respondents were asked to comment on the mixed perspectives heard within this category. People mentioned that financial incentives might not be feasible long-term but could provide a way to begin conversations with agricultural producers. This view is exemplified by the following quote:

> "The financial incentive is the carrot to bring folks to the table. What I've found is that the incentive program brings out the early adopters in an area. Once you have those early adopters on board for a few years you can develop a community of practice by having peer to peer workshops involving a dozen to three dozen implementers. This usually sets off a fervor of activity for those who have seen positive change from adopting some of these practices and encourages them to reach out further when they find a community with similar interests. The projects will be of various sizes from a few dozen acres to a few thousand, but they have a common interest. That common interest drives conversations and outreach that the financial incentive alone could never have accomplished"

Others mentioned that producers must shift their management mindset to think across generations and to create and grow a conservation ethic. Some mentioned that financial incentives must also be long-term to realize this shift, while others mentioned that financial incentives will not cause the ethical shift needed to conserve the Central Grasslands over generations. Here are some quotations that showcase this complexity:

> "Using financial incentives may not be the most effective way to create a lasting conservation ethic. A lasting conservation ethic is held by individuals who value stewardship and practice conservation even when it costs them. It's part of their culture."

> "I certainly agree that creating an overwhelming community ethic toward grassland conservation would make our jobs easier, and working toward as much of that as possible is good. But I think most every rancher out there has at least some of this ethic in them already. Ranching is too hard of work to not feel that grass on the landscape is important.

> If you didn't feel that way, you'd have thrown your hands up in the air and quit a long time ago. So, I think that extra push of making things financially helpful is ABSOLUTELY needed. I think it's really easy for us biologists to sit back and say that if that were me, I'd conserve that grassland even if it didn't benefit me financially. That's just not how life works when you have a family to feed."

Others mentioned that financial incentives can become institutionalized and part of the agricultural culture when they are supported by commodity prices and financial institutions. This was generally seen as a problematic part of financial incentives as demonstrated in the following quotations: "if we only achieve conservation by subsidizing it, it will be gone when the next higher bidder comes along" and "Like most things in present day, land is seen as owing the landowner something and it must be providing something to be worth anything, and usually if it doesn't lead directly to money it is seen as worthless." Respondents also mentioned that cultural shifts must bolster financial incentives for long-term conservation to be achieved.

Finally, respondents mentioned a need to work toward long-term profitability and sustainability of grazing systems to negate the need for incentive payments or that some programs pay for poor management and that financial incentive structure reform is needed.

3.4 Key Findings

Overall, the Delphi study helped identify effective landowner and community engagement strategies and social science research needs that were solicited from conservation delivery practitioners. Landowner engagement strategies that related to targeted conservation delivery practitioner strategies, landowner-led or peer-to-peer conservation programming, and using financial incentives were identified and agreed upon as effective by those who participated in the Delphi survey. Specific strategies agreed upon as effective within these categories focused on the recruitment and retention of conservation delivery professionals by embedding these positions within local communities and hiring practitioners who are experienced with grassland conservation practices. Conservation delivery engagement strategies included developing long-term relationships through one-on-one conversations with producers and having the ability to be patient and listen to producers when discussing different grassland conservation programs or practices. Programs where producers can see the benefits of grassland management from other

producers was mentioned as an effective strategy as well as encouraging and supporting local leaders in becoming conservation champions or encouraging producers to tell other landowners about the benefits of conducting grassland conservation behaviors. Financially incentivizing different grassland conservation actions such as providing cost-share opportunities for grazing infrastructure and other grassland management behaviors was also mentioned as an effective engagement strategy. While the using of the financial incentives category and specific engagement strategies within this category reached consensus related to effectiveness, open-ended responses revealed a lot of nuance surrounding this topic. Many indicated that lasting grassland conservation engagement strategies must go beyond simply paying people to conduct grassland behaviors because financial incentives may not be sustainable in the long term or lead to the development of an individual or community grassland conservation ethic, which was seen as important for lasting conservation of the Central Grasslands.

In relation to research needs, the practitioners in this study identified and agreed upon the importance of a wide range of social science research topics to improve conservation of the Central Grasslands. Most of these topics were associated with the desire to have a better understanding of the social and ecological context of decision-making and the ways in which landowners are making decisions. Many of these research topics related to a desire to understand the relative role of economics in motivating grassland conservation behaviors in conjunction with other variables. As addressed in subsequent sections of this plan, there is a significant body of research on many of these topics. Accordingly, efforts that work to help translate this body of social science research to be more accessible to practitioners and where they work are important. Another area of research identified as important, but less represented in the literature, is on the macrostructures of conservation and the programmatic and policy impacts on how conservation is enacted. Conservation delivery professionals who often work to implement these policies and programs can offer insights into the ways in which these programs translate to conservation outcomes. Focusing on the identified research gap of increasing understanding of how economic incentives and agricultural crop subsidies work against grassland conservation could assist efforts on the ground and can help to refine these programmatic, policy, and institutional structures.

Within the topics raised, opportunities were also identified for increasing conservation practitioners' understanding of conservation social science. Many respondents assumed a deficit

of knowledge among landowners and grassland managers on the outcomes of management. They also suggested that with such knowledge, landowners and managers might choose more sustainable management or production systems. Although this is likely the case in some instances, syntheses such as the framework that was used in the analyses demonstrate that there are many factors that contribute to any decision, and knowledge is only one of these. Thus, increasing the knowledge of outcomes among landowners and managers may have less of an impact than is expected. A similar argument may be made in relation to economics, which were consistently identified as a topic for more research. Importantly, many of the topics were centered on the relative role of economic factors in decision-making, which highlights a need for interdisciplinary research. Landowner engagement strategies related to financial incentives were also agreed upon as effective, yet there was nuance to the importance of financial incentives in promoting grassland conservation actions. While many indicated that financial incentives were an important catalyst to begin conversations between grassland managers and conservation delivery professionals, many also indicated that lasting grassland conservation engagement strategies must go beyond simply paying people to conduct grassland behaviors because financial incentives may not be sustainable in the long term or lead to the development of an individual or community grassland conservation ethic (which was seen as important for lasting conservation of the Central Grasslands).

The use of the conservation decision-making framework of Epanchin-Niell and others (2022) also highlights areas of social science research that were deemed less important by practitioners in the panel of experts. Notably, professionals agreed that research topics in the aggregated behavior category, which included cumulative behaviors across decision makers, were not as important as other topics. This category could include community decision-making, which may also relate to the lack of consensus on categories of community engagement strategies. This may represent a limitation in the representativeness of the practitioners who were sampled in the study, in the way their responses were coded, or may be an accurate reflection of the social science research needs across the study. It may be likely that practitioners perceive their work as centered on building relationships and projects with individual landowners or estates; accordingly understanding the social science related to these interactions is likely most important to their work. Within the Central Grasslands, this emphasis may be less true outside a US context since there were fewer responses from outside of the United States. Although the sample was

initially comprehensive geographically, subsequent rounds of the survey experienced a drop in the number of participants and their geographic representation.

Opportunities to solve grassland conservation and engagement challenges are numerous and may apply at multiple scales. An opportunity exists to support shifts in agricultural policy that protect and elevate the importance of grasslands and support and subsidize grassland conservation actions in ways that make grassland-based agriculture sustainable both financially and ecologically. Although this might not be in the purview of many conservation delivery professionals and may take years to achieve, it is helpful for practitioners to continue to speak to local agricultural policy makers about the importance of grasslands and give recommendations for policy changes that support grasslands and keep producers on the landscape.

4 Plan for Integration of Social Science into Central Grasslands Conservation Efforts

All of the above efforts culminated in a grassland management social science gap analysis, identification of social science research priorities, and integration plan that outlines recommended strategies for integrating social science into the Central Grasslands conservation efforts. This plan was developed in two different steps: the first involved linking the synthesized input provided by the social science community (via meetings, a current research data survey, and the literature review), grassland conservation delivery professionals via the needs assessment Delphi process, and landowners and grassland-based agricultural producers in Canada, Mexico, and the United States who participated in the three country-specific surveys, into a preliminary plan for future integration of social science into grassland conservation delivery. The second step involved presenting the information from the products and synthesized information related to communication gaps, knowledge gaps and research needs, and opportunities for social science integration with social scientists and conservation delivery professionals who participated in the project to gather feedback on the results and integration plan. These combined efforts will serve as a starting point for future actions to bridge gaps, prioritize and fund identified social science needs, and better integrate social science into grassland conservation delivery and management.

4.1 Communication and Information Gaps

Based upon the results of the analyses, there are several communication and information gaps that are evident. The literature review and others have worked to document the increasing body of knowledge that relates to the social science of grassland management. However, many of the social science research needs identified in the Delphi have already been studied extensively by social scientists, indicating that this research is not being conveyed to those practitioners who are working to implement conservation and develop programs and policies to support conservation, representing a communications and information gap.

Given the amount of literature on prescribed burning (see Morton et al, 2010; Harr et al., 2014; McDaniel, 2018; Kreuter et al., 2019; Polo et al., 2020; Jeffries et al., 2023) and voluntary assistance programs related to grassland conservation (see Olenick et al., 2005; Lute et al., 2018; Barnes et al., 2019; Pavlacky et al., 2022; CEC, 2025), it seems that there is significant scientific knowledge related to social science aspects of these practices. Yet, conservation delivery professionals identified that understanding human decision-making around specific grassland conservation practices was an important need. Efforts should be made by social scientists to make these available to delivery professionals and/or to summarize them in a form that they prefer and is easy to apply to their work.

Some additional practices for which there is some existing research, but that some additional work may be needed include:

- Grazing or haying that supports grassland conservation (see Harr et al., 2014; Gruntorad et al., 2021; Adhikari et al., 2023).
- Invasive plant management (Kaur et al., 2020; Ahamad et al., 2022; Roberts et al., 2023).
- Grassland restoration (see Tyndall et al., 2013; Vaske et al., 2021; York & Jager, 2021).
- General rangeland management (see Wimberly et al., 2017; Raynor et al., 2019; Wang et al., 2021; Maestas et al., 2022).

Common barriers to grassland conservation behaviors is another area where there seems to be a gap in communications between social science researchers and conservation delivery practitioners. The barriers that have been described include perceptions related to ability, time and money (Coon et al., 2020), concerns regarding safety and weather related to prescribed burning (Symstad & Leis, 2017; Clark et al., 2022a; Toledo et al., 2013, 2014), and complexity, bureaucracy, and perceived program inflexibility in relation to voluntary grassland conservation assistance programs (Barnes & Dayer, 2021; The Central Grasslands Roadmap, 2021). Economic

constraints and costs of transactions have also been identified as barriers toward effective management (Joyce et al., 2013; Parajuli et al., 2019; Wang et al., 2021).

Predictors of grassland conservation behaviors were also mentioned as important research needs among grassland conservation delivery professionals yet have been extensively studied. Positive attitudes toward management, a sense of moral responsibility to conserve grasslands (Barnes et al., 2019; Coon et al., 2020), and personal and social norms and positive prior management experience (Lawley & Yang, 2015; Stroman et al., 2020) have been associated with increased willingness to engage in conservation activities.

The information and communication gaps that have been identified indicate a need for researchers to help summarize and link conservation delivery professionals to these information sources. Although many efforts (such as the literature review that was conducted as a part of this effort) do exist to help span this gap, more should be done to ensure that this information is communicated and ultimately applied to achieve conservation results on the ground. We're unsure why this research is not getting to grassland conservation delivery professionals. This research may be promoted in forums or places that don't include professionals, or it could be inaccessible in a variety of ways including journal subscriptions or articles being written in such a complex way that professionals are unsure of how the research can be applied to their work. Potential strategies to bridge this gap include asking conservation delivery professionals what formats they would like to receive this information and creating preferred products such as literature reviews, fact sheets, webpages and short presentations, to disseminate applied social science research identified as important and applicable to professionals. Continuing to summarize social science research that is geographically and thematically relevant, and ensuring that these are clearly communicated and made available to conservation delivery practitioners, should be a high priority for the Central Grasslands conservation community.

4.2 Knowledge Gaps and Research Needs

Based upon these analyses, knowledge gaps and research needs have been identified that are understudied, but which are deemed important for study in the future by both conservation delivery professionals and social scientists. Many of the research needs identified in the Delphi included testing or evaluating a specific strategy (e.g., the effectiveness of mailings). The literature review identified few social science studies that employed an experimental design approach to test the effectiveness of specific conservation delivery strategies or communication approaches. This is a social science research method that would provide research results in a way

that is, perhaps, more relatable to the types of agricultural and ecological research that practitioners may be familiar with. Qualitative or inductive research was also a methodological approach that was underrepresented in the literature review. This approach to gathering and analyzing data may also resonate with many grassland conservation delivery professionals.

Another knowledge gap is research that includes multiple scales of analysis. Although many studies were uncovered that focused on the decisions and behaviors of individual grassland managers and some that focused on community-level decisions or sought to make inference at a nationwide scale, relatively few were found that addressed grassland management behavior across scales (e.g., macroscale and producer motivations). While this gap may represent a bias in the literature review methodology, it may also be due to the difficulty in analyzing data and making inference across multiple scales, yet this type of analysis is important. Further, some analyses may be more important at specific scales. Social scientists know that participatory and community-based research is important and conservation delivery professionals often mentioned the need for culture shifts related to grassland conservation values at the community level. However, it is important to think across multiple scales to identify commonalities and differences across scales (countries, states/provinces, regions, etc.), yet test those generalizations at the community and individual level, which is where conservation delivery currently occurs.

Interdisciplinary and cross-social science domain analyses also seem to be missing from the literature and yet were deemed important to study. Many identified research needs related to a desire to consider the relative role of economic and non-economic factors in predicting and understanding a given grassland conservation action. The current review turned up relatively few such studies, which may be due to the relative rarity of collaborations among scientists across multiple social science disciplines (e.g. social psychology, anthropology, rural sociology, economics etc.). These various disciplines also study different scales and aspects of human thought and behavior, which may also be related to the scale issue mentioned above. Interdisciplinary research is often conducted with only one social scientist or social science discipline represented on the team. Additionally, there was an expressed need for understanding outcomes holistically across domains of sustainability or that accounts for the complexity of landowners' social ecological context and decision-making. Such research will need to incorporate interdisciplinary research teams to understand the social and ecological outcomes of a given practice, context, or factors associated with a given behavior.

There would also seem to be a knowledge gap relative to some specific management actions, such as chemical and mechanical treatments for non-native plants, mulching, and mixed-species

herbivory to reduce woody plants or emerging and innovative management approaches, such as the development of new industries that incentivize grassland conservation (Kaur et al., 2020), and unique approaches to land management (Wang et al., 2021; Brammer & Bennett, 2022), which can help to alleviate some of the economic constraints related to conservation.

Identifying these cumulative information gaps can create an opportunity for engagement among researchers in different fields and between scientists who study grassland management and grassland conservation delivery professionals. In applied research fields, one of the outcomes of research is its application and use outside of a research setting. The research gaps that conservation practitioners have identified represent a list of topics for which there is a need and potential for impactful research. The gaps identified here represent topics that are ripe for future research. Researchers can also be encouraged to continue consulting with conservation practitioners throughout the research process.

4.3 Future Social Science Research Priorities

Priority research themes identified here are based on those revealed in the trinational survey synthesis along with knowledge gaps identified from the Delphi study and the literature review. These themes are centered on understanding the sustainability of agricultural production in grasslands across the domains of economics, production and environment. Agricultural production sustainability was identified as a common theme related to desired grassland conservation evaluation metrics that were indicated across all three country-specific landowner and agricultural producer surveys, yet there seems not much existing research related to this topic in the literature review. Furthermore, these research topics were consistently ranked high among conservation professionals. Ultimately these findings can be applied to the development of programs and conservation strategies, possibly via a focus on ecosystem services. Some potential topics related to this type of research are:

- Collecting economic data that demonstrates grassland agriculture sustainability, including the environmental benefits of well-managed grasslands, and their measurable economic impacts (carbon storage, water and nutrient cycle restoration, wildlife habitats).
- Determining how to develop voluntary grassland conservation programs that increase the value of land, based on multiple factors such as net productivity and environmental or recreational services.

- Determining the size of incentives or payments for ecological goods and services that are required to meaningfully reverse the current loss of grasslands and wildlife habitat within them.
- Determining how landowners can best achieve a balance between conservation, management and production.

Additionally, there are opportunities to conduct research that helps understand the social and ecological decision-making context of agricultural production on grasslands in a way that resonates with producers, who view themselves as businesspeople. Such research can be broadened to account for household dynamics, off-ranch income, and the role of larger agricultural policies in shaping grassland conservation decisions. Research topics that compare decision-making across multiple types of agricultural production and focus on whole-operation decisions can help to understand the potential scalability of conservation programs. Such studies were not identified as being well-represented in the published literature, but could include:

- Examining what happens to the economics of grassland conversion compared to other land use types when federal insurances and subsidies are removed.
- Understanding agricultural producers' perceptions of grassland versus cropland profitability, including when federal insurance and subsidies are removed.
- Determining what it would take to convince landowners to implement grassland restoration and conservation practices on their properties instead of other land uses.

Finally, there are research topics that examine and evaluate the effectiveness of conservation delivery professionals and longevity of grassland conservation programs. Such research, if integrated, can improve conservation delivery effectiveness by helping these professionals build trust with grassland managers (Burger et al. 2019, Wilmer et al. 2022) and benefit the development and refinement of training for conservation delivery professions. Furthermore, landowners and managers have identified that well administered conservation programs that are tailored to their needs are more likely to be attractive. Research topics that should be prioritized include:

- Determining the critical steps that conservation delivery specialists are missing when developing relationships with landowners that are hesitant to work with agencies on grassland improvements.
- Understanding post-grassland management practice behavior to support grassland persistence and how to bridge the gap between different voluntary grassland

conservation programs or help landowners plan for the future, once income from incentive payments ends.

- Understanding how to promote grassland landownership and management persistence to reduce the churn rate of grasslands that are converted to other land uses and keep large grassland blocks together.

These priorities are provided as a starting point for conversations between social scientists who may conduct this research and conservation professionals, grassland managers, ranchers and others who will use the data and potentially be affected by the research. Such engagement will necessitate inclusion of the diversity of grassland stewards, including non-white ranchers, Indigenous Nations, and all communities which rely on the Central Grasslands for food, fiber, livelihoods, and essential ecosystem goods and services. Such social science research efforts will require a commitment among funders and researchers to supply the significant resources and social science expertise to ensure that projects are representative of the populations and regions of interest. Together, applications of these findings may help slow the decline of the Central Grasslands and their biodiversity.

4.4 Opportunities for Integration

In this project, it was possible to draw upon the insights of landowners and grassland-based agricultural producers, conservation delivery professionals, and social scientists to identify opportunities for social science integration through the gap analysis and future research priority list. A plethora of opportunities exists for better integration of social science into grassland conservation delivery than was uncovered in the various aspects of this project. However, what was learned from this work was that conservation delivery practitioners would like to learn more about multiple determinants of grassland conservation behaviors and the most effective outreach sources. They also identified that social science information rarely makes it into conservation delivery trainings or within education programs for wildlife biologists. Therefore, integrating insights from pre-existing and geographically relevant social science and communications studies into conservation delivery practitioner trainings both during formal coursework and while being onboarded in a new position might be a good way to integrate social science information to meet the needs of conservation professionals.

Respondents in the Delphi study identified that the way grassland conservation programs are structured and delivered across the Central Grasslands also needs improvement. In the United States, there is a major need to improve recruitment and retention of conservation delivery

professionals by changing the skills and abilities required to secure these positions and hiring practitioners who already live within grassland-adjacent communities. Respondents in Mexico also noted a need to have more conservation delivery professionals who receive standardized training on rangeland management through increased government funding for extension professionals (often employed through universities) and the creation of a conservation delivery professional training certification. Given this need, there is also an opportunity to partner with social scientists to understand and evaluate what characteristics make a successful conservation delivery practitioner and how this might change based on regions. The skills and characteristics uncovered within this research could then be integrated into the future hiring and recruitment of professionals. Asking conservation practitioners at various stages of their career what support and resources they may need to stay in their positions and do their jobs better is another opportunity to improve employee retention. Another possible retention strategy is to shift employee evaluation metrics from grassland acres to metrics that revolve around relationship building and community engagement and empowerment. These opportunities for increased recruitment and retention could improve landowner and community engagement as illustrated in this response:

> "Conservation Delivery and Practitioner Strategies are super effective as well, but the rate of return is very slow because building these relationships takes a long time—you may not see the fruits of your labor for decades—which I think is difficult for many agencies/grants to accept as most jobs and funding sources in the private lands conservation sector require you to report on what you've "delivered" which could look like not a lot if your building long term relationships. Additionally, as a young professional in this field, I think it is difficult to ask people like myself to commit to staying in a community for (the) time it takes to build these relationships—you almost need to target hire local people who intend to live the rest of their life in the community."

There are also opportunities to use and integrate social science expertise into projects aimed at:

- Improving community and private lands conservation programs
- Scaling up grassland conservation efforts to empower community action
- Stimulating the creation of regional, national, and multinational conservation efforts, policies, and
- Developing communication campaigns to promote the importance of the Central Grasslands and efforts to conserve grasslands.

This issue of scale is important to consider and, as mentioned previously, studies that examine grassland conservation actions and policies across scales are important. There is a different level of social science knowledge and integration, agricultural economic policies (that affect grassland conservation), and grassland management and conservation delivery approaches and contexts across and within Canada, Mexico, and the United States. Understanding the nuance of these specific countries, while also promoting learning across them, is essential.

Effective grassland conservation efforts must employ both top-down and bottom-up approaches and processes to maximize effectiveness and return on investment while also building trust and promoting the value of grasslands at the individual and community-level. Additionally, policies to support or undermine grassland conservation often happen at the national level, whereas grassland management decisions and conservation delivery often happen at the individual or community level. Programs must be flexible to the needs of individuals or communities while occurring within a broader regional, national, or multinational framework.

Social science expertise can also help grassland conservation professionals learn about and connect with people who rely on grasslands but have traditionally been underserved by conservation, while developing communication strategies that can reach diverse communities of interest more efficiently and effectively. Incorporating diverse social science inquiry, such as knowledge gained through participatory or community-based approaches or disciplines such as anthropology and sociology, can enhance conservation strategies by addressing community dynamics and marginalized voices. Indigenous Knowledge Systems offer critical insights into sustainable grassland conservation practices, emphasizing the importance of co-producing conservation solutions with these specific communities. Conservation of the Central Grasslands will rely on engaging with Indigenous communities and human populations in addition to white ranchers to co-produce conservation solutions to grassland loss. The use of Indigenous and Western science together can yield more comprehensive information about grassland stewardship and elevate the importance of grasslands to the livelihoods of human communities across the region.

It will also be important to create more opportunities for social scientists and grassland conservation delivery practitioners to interact, communicate, and collaborate so that information is made available and applied by conservation delivery practitioners and that social scientists can continue to conduct research that fills grassland social science knowledge gaps. When feedback was solicited on the results of this integration plan, social scientists and conservation professionals mentioned that publishing this work to identify research gaps, needs, and priorities

might be effective in getting this research onto funding priority lists and encouraging social scientists to conduct this work. They also mentioned that hiring science integration or technology transfer positions who could work to help translate and integrate both biological and social science information into conservation delivery may be beneficial. Further, conservation delivery professionals mentioned the importance of communicating and presenting these research findings in a variety of places, especially places that have a national or multinational focus, and using a consistent messaging approach. Potential communication venues for in-person and virtual presentations include regional conservation and agricultural producer meetings, grassland policy-maker meetings, conferences focused on grassland conservation and management, and the Central Grasslands Roadmap, among others. Learning communities and communities of practice that include both social scientists and conservation delivery professionals were also mentioned for promoting coordination and collaboration. The Central Grassland Roadmap Social Ecological Working Group represents a good starting point to continue these conversations and help determine how a community of practice such as this might be structured and who should be part of it.

Conservation of the Central Grasslands will depend on decisions that are multidimensional and complex, requiring information from the social and biological sciences, Indigenous ways of knowing, and local knowledge. While social science is just one information source necessary for biome-scale conservation, it is essential because human communities rely on grasslands and grasslands are affected by their decisions. Yet, social science has often been excluded from grassland management and conservation delivery efforts. Information from the country-specific landowner and agricultural producer surveys, conservation delivery professional social science needs assessment, and grassland management social science literature review have helped identify social science information and knowledge gaps, identify priority social science research topics for future work, and develop and a plan to integrate social science to benefit Central Grasslands conservation efforts.

This work is not exhaustive. Given time, capacity, and knowledge constraints, implicit and explicit biases, and geographic coverage issues, this work has limitations that were identified within each project component. Despite these limitations, overall, this work provides a good foundation for understanding the current state of grassland management social science, grassland conservation delivery professional social science needs and social science knowledge and information gaps across the Central Grasslands.

This work represents a starting point. Through various elements of this project, a broad network has been created of social scientists and conservation delivery professionals who contributed to this effort and are interested in hearing about and implementing recommendations for integration. The plan is to use this pre-existing expert network to implement recommended integration strategies, begin to bridge social science knowledge and information gaps by sharing the products developed from this project and promote the priority social science research topics identified through this work.

Appendix 1. Landowner and Community Engagement Strategies Listed Within each Category

Summary of Types of Effective Landowner Engagement to Encourage Grassland Conservation

General education and outreach

- Extension programming that raises awareness and demonstrates the balance between conservation and supporting livelihoods.
- Strategic placement of programming and support in areas where there is already good conservation work happening and landowners can see results of conservation action.
- Education about grassland conservation at conservation organization membership events such as Ducks Unlimited or Pheasants and Quail Forever banquets.
- Communication around profit and wealth generation that can be attained through grassland conservation strategies.
- Publications that focus on the benefits of grassland conservation targeted at the general population (not just agricultural producers).
- Connecting grassland conservation and health to a robust livestock agricultural and rural community.
- Using trusted sources of information:
    - Working with cattleman organizations and grassland coalitions to integrate grassland conservation messaging into their events and trainings.
    - Avoiding government (state or federal) sources of information (this could mean practitioners as well).
- Dissemination of the information that is generated about the grasslands. An intense effort must be made so that the majority of people know about grasslands, since it is an ecosystem that is very forgotten by society.

Targeted conservation delivery practitioner strategies (both in hiring practitioners and strategies that the practitioners should use)

- Place long-term biologist positions embedded in local communities and invest in those positions, so they have long-term tenure.
- Hiring practitioners who are experienced with on-the-ground grassland conservation practices and can help with the work.

- Starting long-term relationships through voluntary conservation program conversations.
- Listening to producers' needs and understanding how to make connections between conservation practices and landowner management objectives.
- Listening more than talking.
- Understanding local culture before reaching out to new people about grassland conservation practices.
- Using easy conversations (like promoting a simpler practice) to build relationships and serve as a bridge to conversations about longer term or larger conservation actions.
- Exhibiting patience and realizing that it might take years of conversations before producers take the first step in implementing conservation practices.
- Being able to speak from actual experience of doing the work (burning, cutting trees, etc.).
- Forming strong, long-term relationships with landowners.
- One-on-one in-person communication between practitioners and landowners.
- Joint management of specific pieces of land that help build trust.
- Bringing additional resources (professional help or money) to improve/maintain existing management regimes.

Landowner-led and peer to peer programming

- Landowner-led workshops or peer-to-peer groups where producers can see the benefits of grassland management behaviors from other producers.
- Encouraging and supporting local leaders in becoming conservation champions.
- Encouraging landowners to tell other landowners about the benefits they've experienced from conducting grassland conservation behaviors (word of mouth).

Conservation practice demonstrations

- Field days and demonstrations where landowners can learn by example, see the how and why behind specific conservation practices, and ask questions.
- Show improvements in water quality based on grassland conservation actions.
- Field days focused on soil health.

Holistic conferences and trainings

- Rancher trainings that meld profitability, producer well-being, and environmental sustainability that also include follow-up to see how people are doing with implementing their plans.

Promoting group membership related to grassland conservation

- Membership in local livestock, grazing, or prescribed burning organizations.
- Participation in groups related to sustainable ranching practices in social networks such as Facebook.

Using financial incentives

- Providing cost-share opportunities for cattle grazing infrastructure and payments for grassland conservation actions.
- Promoting perpetual easements that restrict grassland conversion and provide economic benefits to producers.
- Keeping reimbursement for conservation practice processes simple.

Other

- Helping landowners with equipment needed to conduct the conservation work (that they may not be able to afford otherwise).
- No strategy, it depends on the context and the type of actors and their own histories of participation.
- Acknowledgement of the work that ranchers and landowners have done for generations and continue to do to preserve the remaining grasslands is helpful. They are already conserving the remaining grasslands but whether that will be feasible in the future is the key to conservation.
- Policy protections such as conservation agreements with assurances or safe harbor agreements (in the United States) that ensure landowners are protected from future regulatory actions if they voluntarily participate in grassland conservation and stewardship. Having these tools in place would make it easier to engage on other conservation strategies.

Summary of Types of Effective Community Engagement to Encourage Grassland Conservation

General education and outreach

- Education and outreach on specific conservation topics on social media (such as Facebook).
- Education on the complexity of grassland ecosystems. Once people realize there is an abundant amount of plant and wildlife diversity in these systems they seem to have a much stronger appreciation for them.
- Teaching about grassland conservation and helping those in the community do the conservation work.
- Marketing and communications campaigns uplifting grasslands in the public consciousness.
- Environmental education in schools with parental participation.
- Dissemination of the information that is generated about the grasslands. An intense effort must be made so that the majority of people know about grasslands, since it is an ecosystem that is very forgotten by society.

Coordination of education and outreach

- Coordinated engagement and messaging on grassland conservation from all conservation entities in a community.

Targeted conservation delivery practitioner strategies (both in hiring practitioners and strategies that the practitioners should use)

- Hiring practitioners who understand the complexities of communities but are willing to listen to find common issues for producers within communities.
- Talking with community members about conservation when you're not necessarily at work such as grocery shopping.
- Connecting with people about conservation at non-conservation events attended by a large number of community members. These could be church events, schools, youth sports events, or 4-H meetings.
- One-on-one communication between practitioners and landowners.
    - Providing constant support to small land holders/ranchers.

Conservation practice demonstrations

- Community-wide workshops and events focused on grasslands.

- Using public hunting access on private lands programs to showcase the beneficial effects of grassland conservation strategies.
- Showing improvements in water quality and availability resulting from grassland conservation practices.
- Showing improvements in wildlife habitat as a result of grassland conservation practices.

Promoting group membership related to grassland conservation

- Membership in local livestock, grazing, or prescribed burning organizations.

Using financial incentives

- Paying those within the community to help with grassland conservation work such as herding/cowboying.

Supporting Community-Led Grassland Conservation Efforts

- Community-led efforts where conservation delivery practitioners support those in community who are doing the work and encourage them to share with others.
- Grassland conservation initiatives that start from within the community (grass-roots) that reach one producer at a time.
- Areas voluntarily designated for conservation where private or communal landowners agree to sustainably maintain their properties over a period of 15-99 years. This strategy exists in Mexico and is similar to long-term easements in the United States.
- Getting diverse groups of stakeholders together to reach consensus on local rangeland needs.
- Maintenance of in-person social networks focused on grassland conservation issues.

Other

- Acknowledgement of the work that ranchers have done for generations and continue to do to preserve the remaining grasslands is helpful. They are already conserving the remaining grasslands but whether that will be feasible in the future is the key to conservation.
- Formation of multi-sector alliances that operate in a horizontal and participatory manner.
- No strategy, it depends on the context and the type of actors and their own histories of participation.

Appendix 2. Compiled Social Science Research Topics

Compiled research topics that were gathered during the first round of the Delphi survey and scored during the second round of the Delphi.

Social Ecological Decision-making Context

- Determining what changes to the landowner socio-political environment are necessary for positive grassland change
- Understanding the role that regulations and law enforcement play in the management decisions of landowners
- Determining what factors are necessary to conserve grasslands in agriculturally dominated regions
- Determining how to develop voluntary grassland conservation programs that increase the value of land based on multiple factors such as net productivity, and environmental or recreational services
- Determining the strength of economic factors pushing people to convert grasslands to other land use types
- Examining what happens to the economics of grassland conversion to other land use types when federal insurances and subsidies are removed
- Determining how to get the government to use conservation or human well-being metrics (as opposed to gross domestic product) to determine success
- Determining the necessary skills and experiences needed to create effective policy leaders for grassland conservation
- Determining the price the public is willing to pay to support grassland managers
- Determining how to convince consumers to pay more for food that is produced on lands with good conservation ethics
- Examining the best ways to develop larger economic support programs for agricultural producers
- Determining whether social programs that pay ranchers to stay on the land increases grassland conservation
- Understanding public perceptions of healthy grasslands, cattle production, and threats to grasslands (such as woody plant encroachment) versus their perceptions of these factors in other ecosystems
- Understanding the landscape differences in societal attitudes towards government and conservation
- Understanding how people value and connect to grasslands across the region

- Determining whether urban resident support of ranchers increases when they visit rural grassland locations
- Determining current and new employment opportunities that grasslands can offer to integrate new sectors and populations into grassland regions
- Understanding how the rural mental health crisis affects grassland conversion
- Determining the critical steps that conservation delivery specialists are missing when developing relationships with landowners that are hesitant to work with agencies on grassland improvements
- Understanding how the high turnover of biologists impacts an agency's ability to deliver conservation programs
- Determining the level of involvement or follow-up that is desired by landowners and managers when participating in voluntary grassland conservation incentive programs
- Understanding whether landowners recognize the value, threats and loss of grasslands.
- Determining the barriers keeping people from managing their grasslands long-term.
- Understanding livestock producers' willingness to change management and why some are reluctant to use certain practices (e.g., fire, herbicide
- Determining how to convince inherited landowners to change generational practices and try new practices
- Determining how to increase agricultural producer acceptance of grassland conservation
- Determining whether appealing to culture and connecting people with the land will grow interest in conservation
- Understanding the various factors (such as fiscal constraints, concerns, hesitation to working with state or federal agencies) that contribute to landowner resistance to management practice change
- Determining the amount of money that would convince landowners to make production/management changes on their operations
- Understanding agricultural producers' perceptions of grassland versus cropland profitability, including when federal insurance and subsidies are removed
- Determining what landowners are willing to pay for conservation practices that would benefit grasslands
- Determining who are the actors relevant to grassland conservation, how they identify themselves, and what their goals, needs, interests and experiences are
- Understanding landowners' motivations for restoring or destroying grasslands and how money factors into this
- Understanding individual motivations to participate in voluntary grassland conservation incentive programs

- Determining how conservation professionals can create more internal motivation in landowners to address grassland issues
- Understanding key non-financial motivations for protecting grasslands
- Determining the barriers to implementing conservation practices and supports that would help landowners overcome those barriers
- Understanding the factors that determine why some landowners do not control woody tree encroachment on their grasslands such as lack of time, manpower, financial, etc.
- Determining the barriers to adopting fire or using herbicides on grazing lands
- Determining the barriers to implementing prescribed grazing plans
- Examining why livestock producers don't incorporate native forage species into their operations and what factors are preventing more farmers and ranchers from planting native grasses as compared to non-native cool season grasses such as fescue and brome
- Determining knowledge of and attitudes toward conservation easements in Indigenous communities and whether they support the use of easements to conserve grasslands on tribal lands
- Understanding the perceptions of tile drainage as a land management tool versus the science of the actual function of tiles
- Determining what it would take to convince landowners to implement grassland restoration and conservation practices on their properties instead of other land uses
- Determining the profitability in operations that seek to restore grassland health, rather than just producing beef or a crop
- Determining whether adding insurance policies to help grasslands would help convince landowners to keep their land in grass versus convert to cropland
- Determining how realistic it is for most landowners to pay cost share on grassland conservation practices through programs (such as the United States Department of Agriculture Environmental Quality Incentive Program)
- Examining the relative economics of different grassland conservation practices and if and how these economic factors help stop the breaking of native sod and increase lands enrolled in conservation programs (e.g., Conservation Reserve Program grasslands) from being converted to crops

Consequences (Perceived and Actual)

- Examining the adverse impacts to landowners of planting eastern redcedars and the benefit of removing them
- Understanding the costs, benefits and risks of prescribed fire

- Quantifying the goods and services that grasslands provide and how they contribute to quality of life
- Quantifying the positive impacts of conservation work being done on grasslands and how these are being interpreted by the general public within a region
- Collecting economic data that demonstrates grassland agriculture sustainability including the environmental benefits of well managed grasslands, and their measurable economic impacts (carbon storage, water and nutrient cycle restoration, wildlife habitats)
- Understanding the economic impacts of overgrazing or the conversion native prairie.
- Improving understanding of the economics of production (livestock production, hay production, seed production, etc.) on perennial grasslands
- Improving understanding of the profitability of grasslands
- Identifying ways to empower the general public to conserve grasslands
- Determining whether the decrease in ranching succession (keeping ranches within families) is a result of large-scale operations decreasing community support
- Determining the level of economic and community support that would increase the number of ranches that stay within families (ranching succession)
- Determining the size of incentives or payments for ecological goods and services that are required to meaningfully reverse the current loss of grasslands and wildlife habitat within it

Belief Formation and the Decision-making Context

- Determining what information would help people acknowledge that grasslands are a valuable natural resource
- Identifying what information triggers a response from those who are not vested in grasslands such as agricultural, economic and/or ecological information
- Determining what outcomes a grasslands manager needs to show to receive economic benefits that are supported by the public (e.g. biodiversity benefits, lost economic opportunity, costs to manage, simple presence/absence of grasslands)
- Identifying the best social and economic metrics to measure and monitor related to rural community health or resilience, especially in intact grasslands, and how to measure them (e.g., proportion of land owned by locals, proportion of businesses based locally, number of kids in the schools)
- Identifying ways to educate groups (agricultural producers, federal/state land management agency employees, and the general public) so they understand the difference between conservation and preservation and the role each plays in working landscapes and species habitat

- Identifying ways to improve communications with the general public and landowners so they have a better understanding of the importance of conserving the Central Grasslands
- Determining ways to develop effective extension programs, environmental education, technical advice, and stewardship materials for new landowners
- Evaluating the effectiveness of landowner mailings to identify how (format, wording, type of mailing) to increase landowner response rates
- Determining how to use other rangeland improvements as a way to introduce landowners to alternative project ideas
- Determining the planning steps that landowners take when deciding to convert native grasslands to another land use type and what role financial factors play in this decision process
- Determining how landowners can best achieve a balance between conservation, management and production
- Examining the reasoning behind overuse of grass and water resources
- Determining the barriers that keep people from managing their grasslands long-term.
- Understanding why agricultural producers resist adaptation in their operations
- Understanding what it would take to help landowners integrate more innovation into their decision-making
- Understanding post-grassland management practice behavior to support grassland persistence and how to bridge the gap between different voluntary grassland conservation programs or help landowners plan for the future once income from incentive payments end
- Understanding how to promote grassland landownership and management persistence to reduce the churn rate of grasslands that are converted to other land uses and keep large grassland blocks together

Aggregated Behaviors

- Quantifying the impacts of corporate agriculture on farming succession to help educate new decision makers regarding conservation-based decisions

Appendix 3. Feedback Received About the Research Topic Categories During the Third Round of the Delphi Process

Social Ecological Context of Decision-Making

- Perhaps an analysis of values and attitudes about pastoralism, of several of the answers to the questions.
- Barriers to conservation generally is more important than specific types of conservation practices except in some limited areas for certain species.
- The willing to pay question is very interesting because I think it could be looked at from four perspectives: what are landowners willing to pay, what is the public willing to accept in terms of grassland quality, and then what is the public willing to pay for grassland quality, and what are landowners willing to accept to implement conservation on their lands. That might help to put into context that if a landowner is willing to pay X amount of dollars, but they expect Y amount in return from the public through tax dollars to achieve a certain goal, we need to see how these expectations align or differ. Because for all we know, despite EQIP already being a massive program, maybe the public is willing to pay even MORE if it means ensuring the protection of this critical resource.

Belief Formation and Decision-Making Process

- Determine how the transgenerational division of land is ending with the desired or required income at the level of families and their members.
- The first question [unsure of question they were randomly assigned] has strong implications to my previous comment about willing to pay versus accept. How much money can the public and ranchers put together to create an acceptable quality of grassland that can support the rancher's livelihood along with the public's interest to maintain ecosystems health? I see conservation programs as short term, public dollars that are far greater than any single rancher are able to pay for the high upfront costs often associated with conservation, so long as there is a guarantee that the long term, lower costs will be paid by the landowner to maintain grassland integrity.

Consequences of Decision-Making

- Understand historical changes in grassland conditions caused by livestock production and grazing "fads" or systems.
- The role of community management.

- I think one thing missing, specifically, from the economic selections is the understanding of the TRUE cost of annual crop agriculture. I can talk till I am blue in the face about grassland profitability, but I will never be able to compete with Joe Farmer who gets all the subsidies in the world to produce just corn and beans and as much of those as humanly possible. Being able to show that annual agriculture not only doesn't feed the world but is a giant cost to the American taxpayer, not only in regards to subsidies, insurance, price locks, and CRP schemes, but also for healthcare, medicaid, and food prices, would be a giant eye opener for people and shift perception towards a more sustainable method of farming.
- If possible, regional representation across the diverse agriculture regions.
- It shouldn't be about ecosystem services, it should be about profitability of perennial grasslands as working landscapes and production systems on them that are most profitable and provide good management.
- The topic I ranked as second most important [Improving understanding of the economics of production (livestock production, hay production, seed production, etc.) on perennial grasslands.] is valuable to a biologist because it benefits our ability to better see how conservation programs fit within a livestock operation rather than vice versa.
- When faced with people who are more "Traditionalist", being able to explain what parts of a ranching operation are benefited by what conservation program makes a farmer/rancher much more comfortable when they're in the presence of someone who can talk their talk.

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