Climate-Smart Practice Adoption and Carbon Markets in Minnesota

Hubert H. Humphrey School of Public Affairs
University of Minnesota

Maddie Hansen-Connell
Kathleen Murphey
Jacqueline Oakes Bui
Megan Schmaltz
Ian Williams

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Instructor: Elise Harrington, Assistant Professor

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Glossary

Additionality: the principle that carbon markets should incentivize activities that would not occur under "business-as-usual" conditions (Schulte & Jordahl, 2022). In other words, the sequestration of carbon above and beyond the recognized baseline of current atmospheric or soil carbon.

Cap-and-trade: a government regulatory program designed to cap the total level of emissions from industry activities.

*Carbon Credit*s: a permit that allows the owner to emit a certain amount of carbon dioxide or other greenhouse gasses.

Carbon Inset: a company offsetting its emissions through a carbon offset project within its value chain.

Carbon Offset: a reduction or removal of emissions, or an increase in carbon storage that is used to compensate for emissions that occur elsewhere.

Climate-smart practices: refers to farming practices such as no till, cover cropping, conservation cover, perennial plantings, etc. that are considered good for the environment, prepare farms to be more resilient in the face of climate change, reduce GHG emissions, and have the potential to sequester carbon

Ecosystem services: any positive (direct or indirect) benefit that wildlife or ecosystems provide to people.

Greenhouse Gas (GHG): gasses that trap heat in the atmosphere, such as carbon dioxide and methane.

Perverse Incentives: A perverse incentive is an incentive that has an unintended and undesirable result that is contrary to the intentions of its designers.

Stakeholders: are individuals, groups, or organizations with an interest in a company and can either affect or be affected by a business' operations and performance.

Tilling:

- *Low*: minimum disturbance to the soil
- *No*: no soil disturbance
- *Strip*: uses minimum tillage and only disturbs the soil that contains the seed row

Voluntary Carbon Market (VCM): encompasses all transactions of carbon offsets that are not purchased with the intention to surrender into an active regulated carbon market.

Executive Summary

Climate change is a major concern globally and locally, and agriculture can help mitigate emissions through climate-smart practices. To capitalize on this carbon sequestration opportunity, agricultural carbon markets are emerging in Minnesota and elsewhere as a way to compensate farmers for their role in reducing emissions and carbon sequestration. However, there are barriers and concerns with carbon markets and adopting climate-smart practices. The Minnesota Department of Agriculture (MDA) was interested in investigating the gaps in current carbon market payment systems, policy mechanisms or other solutions, and the most appropriate role for MDA to play in increasing climate-smart practice adoption.

To explore these questions, our research team conducted a background literature review with a stakeholder analysis and completed 26 key informant interviews with farmers and representatives from government, education, business, and others. Key interview themes are included below.

Barriers for Implementing Climate-Smart Practices

- **Financial barriers**: adopting new practices requires a lot of upfront costs, particularly around equipment, and requires taking on financial risk, especially around profitability.
- **Educational barriers:** new practices have a learning curve and farmers need to know how to implement practices and the benefits they provide. There is also a general concern that the science around carbon sequestration potential is murky and variable.
- **Uncertainty and risk:** farmers are uncertain about the science, impacts on yields, and social repercussions from changing practices.
- **Environmental variability:** soil types and landscapes vary widely across the state and different climate-smart practices may be more or less effective in different areas.
- **Structural issues:** while not as prevalent, interviewees did note challenges with land tenure, crop insurance, and a lack of supply chain for alternative crops as barriers.

Carbon Market Awareness and Impacts

- **Awareness:** there is a strong perception that farmers are aware of carbon markets and are being approached to participate, however farmers are cautious to join.
- **Potential benefits:** carbon markets could ultimately lead to climate-smart practice adoption and climate benefits through increasing conversation, community, and awareness, and rewarding interested farmers with extra financial support.
- **Carbon market skepticism and challenges:** most interviewees noted that farmers are skeptical of carbon markets. There were concerns about who benefits from carbon markets, what happens if emissions reductions do not bear out (either due to science or specific on-farm challenges), and the actual impact carbon markets will have on changing practices. There were also concerns around contracts and potential exclusion from future program eligibility.
- **Additionality and perverse incentives:** look back periods and some type of reward or recognition could help overcome issues around additionality for those doing pre-existing practices. Most agreed it is unlikely that farmers who were doing climate-smart practices would stop doing them and then restart to participate in carbon markets. However, they noted it is more likely people will wait to see how markets play out.

Types of support and potential solutions

- **Government involvement:** there were mixed perceptions on governmental involvement with some favoring more involvement, some wanting no involvement, and some noting that MDA may already be in the right role.
- **Financial and equipment support:** provide stronger financial incentives for climate-smart practice adoption, including funding benefits beyond carbon markets; create or expand loan and grant programs to increase access to equipment; and continue funding research and innovation.
- **Education and technical assistance:** share clear data, examples, and proof-of-concepts for practice benefits and help farmers navigate carbon market processes.
- **Network building:** bring farmers together for farmer-to-farmer sharing and form or enhance cross-agency partnerships.
- **Carbon market standardization and transparency:** standardize carbon markets around carbon sequestration measurement, verification, and contracting terms, while also maintaining flexibility for farmers. Additionally, be transparent and hold companies accountable, ensuring farmers are being fairly compensated and emissions are reduced.
- **Structural changes:** potentially rethink the way the market strongly encourages corn, soybeans, and livestock, and consider broader ecosystem services from climate-smart practice adoption.
- **Support for specific groups:** support Black, Indigenous, and people of color (BIPOC) farmers, farmer-centric organizations, and small-midsize farming operations in taking advantage of opportunities.
- **Program leverage**: leverage existing programs and look at other carbon market examples for successes and failures.

Recommendations for MDA

Interviewees offered a wide range of solutions; we feel the following are most appropriate for MDA.

Finances and equipment

1. Offer financial support, especially for benefits outside of carbon markets (e.g. water quality improvements, soil health improvements). This could apply to both new and existing practices.
2. Create or expand loan/grant programs to fund equipment for climate-smart practices. Work with soil water conservation districts (SWCDs) to provide equipment sharing or trials.
3. Advocate for carbon sequestration research/innovation and expanded markets for crop variety.

Education and network building

4. Provide education and technical assistance (disseminate research findings, provide successful farm examples or proof-of-concepts, etc.).
5. Enhance partnerships with agencies and support network-building opportunities for farmer-to-farmer sharing and social support systems. Increase support to BIPOC farmers, farmer-centric organizations, and small-midsize farming operations.
6. Provide guidance around carbon market participation, serving as a navigator for farmers.

Structural changes

7. Push for the United States Department of Agriculture (USDA) or another federal entity to create standards for carbon markets and hold companies accountable.
8. Leverage existing programs, especially the Minnesota Agricultural Water Certification Program (MAWQCP). Support programs that focus on system-wide or other ecosystem service benefits.
9. Create a way to broadly recognize farmers doing these practices.

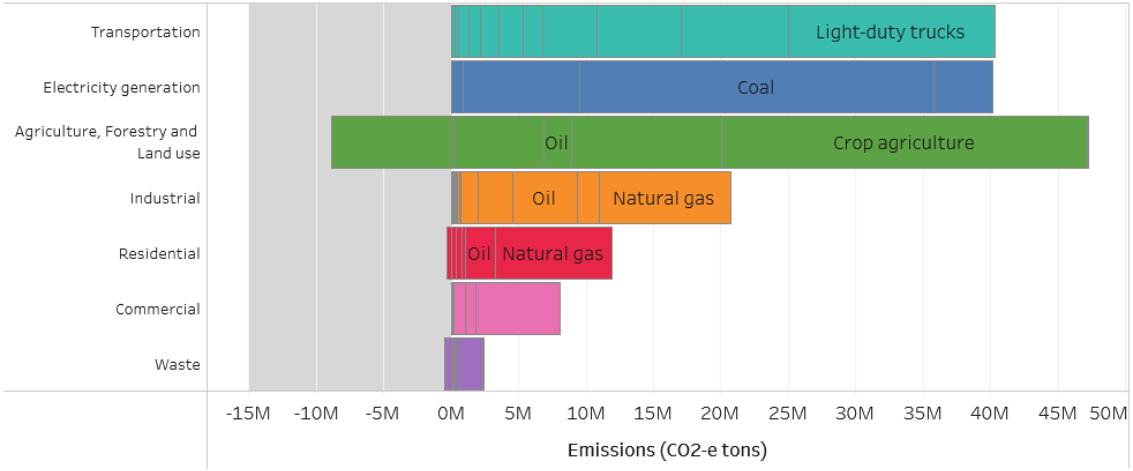
Introduction

Climate change is perhaps the greatest challenge of our time. Within the United States, Minnesota is one of the fastest-warming states, and home to two of the three fastest warming cities (Bjorhus, 2019). Minnesota has already seen a three degree increase in average temperature and a significant increase in rainfall over the past century (DNR, 2021). These trends are projected to continue. In order to curb emissions and slow global warming, we need to take drastic measures in multiple sectors.

According to the Minnesota House Climate Action plan, the goal for the state of Minnesota is to reach 100% carbon neutrality by 2050, with a midpoint benchmark of reaching a 45% reduction in greenhouse gas emissions by 2030. This is a more aggressive plan than the 2007 Next Generation Energy Act that aimed for an 80% reduction in greenhouse gas emissions. However, Minnesota is currently behind in both goals (Minnesota House Climate Action Caucus, 2020).

In Minnesota, agriculture, forestry, and land use as a combined sector make up the largest source of greenhouse gas emissions (Figure 1). This sector has also played the biggest role thus far in offsetting climate change effects, particularly through forest regrowth. The agricultural sector, therefore, has the potential to both reduce its own greenhouse gas emissions and potentially provide a sink to offset emissions in other sectors. This can be achieved through adopting agricultural climate-smart practices.

Figure 1. 2018 sector sources of GHG emissions and storage in Minnesota, MPCA



Source: MPCA, 2021

Many farmers in Minnesota already incorporate climate-smart practices into their land management. However, Minnesota farmers are not participating in these practices to the extent possible. Efforts to establish a private-sector marketplace for carbon and environmental services can augment value and potentially drive an increase in these practices. However, there are many challenges involved, including additionality, which may limit or prevent placing value on or providing payments for pre-existing agricultural conservation efforts. Because of this, MDA was interested in exploring carbon markets and climate-smart practice adoption in Minnesota.

Research Questions, Strategy, & Methods Overview

To explore carbon market dynamics and MDA's potential role, our key research questions included:

1. What gaps exist in carbon market payment systems for reaching ag-based climate goals?
2. What policy mechanisms could be effective in increasing and maintaining farmer participation in climate-smart practices?
3. What is the most appropriate role for MDA in supporting farmers and implementing climate-smart practices?

To investigate our research questions, we focused on two primary activities: a literature review and key informant interviews. The literature review utilized documentation provided by MDA, as well as recent literature and commentary on carbon markets and climate-smart practices with an agricultural focus whenever possible. The literature review also included a stakeholder map for MDA's internal use.

The remainder of the project was focused on key informant interviews and qualitative analysis. The list of key informants was drafted by MDA and all interviews were voluntary. Once interviews were complete, they were coded using a qualitative research method approach. After coding, findings were distilled and recommendations were formed. For the interview protocol and a more detailed description of the methods used in this project, please see Appendices A and B.

Literature Review

Carbon Market Context

Regardless of industry, there are currently two types of carbon markets, voluntary and compliance. Compliance markets are regulated by governmental entities through cap-and-trade. Voluntary markets (VCMs) are unregulated with carbon credits being traded through private companies. At the time of this writing, the only agricultural-based carbon markets in the state of Minnesota are voluntary. In agricultural VCMs, farmers are compensated "for the generation of agriculture carbon credits as well as other ecosystem services such as improvements in water quality" (Plastina & Wongpiyabovorn, 2021). Often, carbon credits are purchased by businesses or corporations as greenhouse gas (GHG) emission offsets. Additionally, VCMs allow farmers to see the benefit of carbon sequestration through a direct revenue stream (Peikes, 2021). Some programs provide farmers the opportunity to sell carbon insets to companies that use agricultural commodities, such as food and beverage companies looking to reduce their emissions in their overall supply chain (Plastina & Wongpiyabovorn, 2021). ***Throughout this report, the term "carbon markets" is synonymous with VCMs unless specifically stated otherwise.***

Carbon Market Functions

To enter into VCMs, farmers must first determine their baseline as it relates to carbon sequestration through current farming practices. Typically, to be compensated through VCM contracts farmers must sequester additional carbon above and beyond their baseline using current practices. This concept is known as ***additionality,*** meaning the farmer must implement new or additional climate-smart farming practices to sequester *additional* carbon. The carbon credit is typically generated by following a set of

verification protocols created by the company itself or a third-party organization. Finally, carbon credits are verified by the company or a third party using the selected verification protocols as a guide.

Climate-Smart Practices

Climate-smart practices include a wide range of on-farm practices that are considered good for the environment, prepare farms to be more resilient in the face of climate change, reduce GHG emissions, and have the potential to sequester carbon. Often, these practices have additional benefits that can broadly benefit the environment, such as water quality and soil health improvement. Examples of practices already being implemented by some farmers are reduced tillage, cover crops, crop rotation, and reduced nitrogen application (Plastina & Wongpiyabovorn, 2021).

The Minnesota Pollution Control Agency (MPCA) investigated twenty-one agricultural best practices to explore emissions reduction potential (Table 2). Thirteen of these practices were designed and employed to reduce nutrient runoff and soil erosion. An additional eight practices with other ecosystem service benefits were included for preliminary results. As shown in Table 2, twelve of the thirteen agricultural practices investigated had a positive impact and reduced GHGs (Ciborowski, 2019).

Table 2. Estimated Annual Greenhouse Gas-Avoidance from Agricultural Practices (CO_2 - equivalent short tons per 100,000 acres per year)

Cropland Idling or Related Conservation Land-Uses	tons per 100,000 acres per year [a,b,c]	Tillage and Cropping Changes	tons per 100,000 acres per year [a,b,c]
Final Results			
Shelterbelts/hedges	(269,000)	Cropland to hayland	(121,000)
Cropland idling in trees	(263,000)	Crop rotation with perennial forages	(50,000)
Forested riparian buffers	(203,000)	No-till, reduced tillage counterfactual [d]	(23,000)
Cropland idling in grass	(162,000)	Cover crops	(20,000)
Field boders and related	(161,000)	Reduced tillage	(15,000)
Riparian grass buffers	(77,000)	No-till	(14,000)
		Continuous corn to corn-soybean rotation	40,000
Preliminary Results-Only			
Cropland Idling or Related Conservation Land-Uses	**tons per 100,000 acres per year [a,b,c]**	**Nutrient Reduction Practices**	**tons per 100,000 acres per year [a,b]**
Constructed/restored wetlands	66,000	Biochar	(120,000)
		Controlled release fertilizers	(27,000)
		Nitrification inhibitors	(24,000)
		Split fertilizer application	(13,000)
		15% fertilizer reduction	(6,000)
		Spring N fertilizer application	2,000
		Subsurface N fertilizer application	31,000

[a] negative = emissions-avoided; positive = emissions increase

[b] descriptive statistics for the soil organic carbon, direct soil N_2O and soil CH_4 oxidation components of each emissions-avoided estimate are shown for in Tables 11-13, 15-17, 19-21, 24-26, 28-30, 33-35, 38-40, 42-44, 46-47, 50-51, 53-54 and 57-58 and Appendices A-H.

[c] for terrestrial carbon sequestration, assumes 20 years of sustained storage of newly sequestered organic carbon in soils and biomass

[d] counterfactual = base tillage condition against which the effect of no-till is evaluated

Source: Ciborowski, 2019

Current Efforts

Federal Efforts

In 2021, the U.S. Senate passed the Growing Climate Solutions Act; it is awaiting passage in the U.S. House of Representatives. This Act supports the development of a voluntary market for agriculture credits derived from carbon sequestration and the prevention, reduction, or mitigation of GHGs on agricultural land (USDA, 2021). The Act also creates a voluntary certification program to be managed by the USDA to help solve technical barriers to entry that could prevent farmer participation in VCM programs (Plastina & Wongpiyabovorn, 2021).

In February of 2022, the USDA also announced it would invest $1 billion into climate-smart practices for farmers, ranchers, and forest landowners. This funding will be provided to partners through the USDA's Commodity Credit Corporation for pilot projects that incentivize producers and landowners to implement climate-smart practices and innovate new ways to measure and verify GHG benefits. One goal of this project is to "create market opportunities for commodities produced using climate-smart practices" (USDA, 2022). This funding increases financial incentives and could reduce some of the barriers farmers face when adopting climate-smart practices or joining VCMs.

Currently under the Farm Bill, the USDA Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP) provide financial assistance to farmers. Under an EQIP contract, farmers can receive funding for the implementation of certain practices and additional financial assistance if they qualify as having limited resources. Under a CSP contract, farmers can receive payments for implementing new practices with a portion of related costs being covered (Reilly et al., 2021). Another notable area is the conservation portion of the 2023 Farm Bill which could include funding for programs, climate strategies for agriculture, compliance provisions, and program flexibility (Good, 2022).

Iowa's Carbon Sequestration Task Force

Of the Midwestern Corn Belt states, Iowa is one of the locations with the most potential for carbon sequestration due to its vast agricultural landscape (Schulte & Jordahl, 2022). Although carbon markets in Iowa are still emerging, the state has taken substantial action to review the validity of VCMs and develop a potential action plan from a state level. This has been done through the development of the Carbon Sequestration Task Force authorized on June 22, 2021, by Iowa Governor Kim Reynolds under Executive Order Number 9. Task A of this executive order identifies several goals, "Reviewing the research on carbon sequestration, considering any gaps in current assessments, and determining whether new research, standards, or definitions should be developed" (Schulte & Jordahl, 2022). To achieve this, the task force engaged researchers at Iowa State University (ISU) to assess the science supporting agriculturally based carbon markets. This emerging effort could help inform carbon market activity in Minnesota.

Current Available VCMs

Using research from Plastina and Wongpiyabovorn (2021), we were able to synthesize data from ten different VCM companies in Table 3, *Carbon Market Requirements and Terms.* This section provides an overview of different program requirements, credit generation protocols, contract terms, and payment

schemes. The four paragraphs below offer a high-level overview of these dimensions. For additional details, see Table 3.

As can be seen in the *Minimum Acres* & *Eligible Crops* columns, many of the VCM programs have no minimum acreage requirement to enroll. Nori requires the most acres, with a 1,000 acre minimum. The eligible crops are similar across programs with corn, soybeans, and wheat being the most common. While Nori requires the most acreage, they also allow the most diversity when it comes to eligible crops. This includes more standard row crops like corn, soybeans, and wheat, but also broccoli, carrots, lettuce, strawberries, and tomatoes, among others. It also includes orchard/vineyard crops such as avocado, grapes, nuts, and citrus. Covered practices are also similar across companies. No or reduced tillage is covered by all companies. Cover crops, nitrogen management, and crop rotation are covered by the majority of companies.

Many companies who issue carbon credits use third parties to generate and/or verify the credits which can be seen in the *Credit Generation* and *Credit Verification* columns. For example, under Corteva's program, the climate-smart practices are registered through a third-party and the data is shared with the Ecosystem Services Market Consortium (ESMC) who quantifies soil carbon storage and certifies carbon credits. During the verification process, Corteva performs the soil samples and ESMC performs the verification. ESMC has its own carbon market but also works with other voluntary programs on credit generation and verification processes. Other examples include: Microsoft partnering with TruTerra who is working with third parties such as the Soil Health Institute, Nori, and Bayer to develop credit generation protocols; and IBM, Anheuser-Busch, and JP Morgan Chase all having agreements with Indigo Ag who works with Verra for carbon credit generation (Plastina & Wongpiyabovorn, 2021). It should be noted that currently, there are no universal standards for verification protocols in ag-based VCMs.

Contract lengths and payment schemes are also variable within VCMs. The *Minimum Contract* column shows the average contract length to be 7 years. Many of the VCMs are reliant on market conditions for new carbon credit payments, with most of them hovering around $15-20 per new carbon credit (*Payment per Carbon Credit column).* Bayer utilizes an alternative approach and instead pays farmers for new practices implemented (up to $9/acre). This means farmer compensation can vary not just from company to company but also from farming practice to farming practice. Uniquely, Nori is planning on providing payment via cryptocurrency (Plastina & Wongpiyabovorn, 2021). While not currently launched, Nori's cryptocurrency, Nori Carbon Removal Tonne (NRT), will represent one tonne of CO_2 removed from the atmosphere. They will be able to be sold directly to individuals and organizations seeking to mitigate carbon emissions, potentially allowing for broader participation in carbon markets (Kamps, 2022).

Several companies are making an effort to integrate farmers' recently adopted climate-smart practices into their compensation models. The *Payment for Past Practices/*CO_2 *Removal* column shows that some companies do not offer payments for previous climate-smart practices while others are paying farmers for 2-5 years of previous or current climate-smart efforts (Plastina & Wongpiyabovorn, 2021). Payments for past practices are often referred to as "***lookback payments***," and these are closely connected to the challenge of additionality. Since one goal of carbon markets is to draw down additional carbon, beyond current levels in the soil and atmosphere, there is debate about the relevancy and importance of payment for past practices.

Table 3. Carbon Market Requirements and Terms

Company	Min. Acres	Eligible Crops	Covered New Practices	Credit Generation	Credit Verification	Min. Contract	Payment per Carbon Credit	Payment for Past Practices/CO_2 Removal
Agoro Carbon Alliance	500 acres	Corn, soybeans, and wheat, with options for other cash crops.	No or reduced till, cover crops, N and, pasture management, degraded and livestock lands.	Uses Gold Standard Registry, field testing, and soil analysis.	Follows Gold Standard Registry verified by SustainCERT	10 years	$10/acre for more than 2,560 acres.	N/A
Bayer	10 acres per field	Corn and soybeans, can rotate with wheat	No-till, strip-till, and cover crops	N/A	Third-party	10 years	Up to $9/acre for new practice implemented	Single payment for up to 5 years of past practices after 01/01/2012
CIBO Impact	None	All crops	No-till, low-till, cover crops, diversifying crop rotation, nitrogen application.	Own carbon registry; credits based on a model developed at MSU.	Satellite data, audit of soil sampling	1 year	$20 per carbon credit for pilot. Farmers set carbon credit prices.	None for removal can be generated from ongoing practices.
Corteva	None	Corn and soybeans	Strip or no-till, cover crops, reducing nitrogen application.	Practices registered in Granular Insights platform. ESMC quantifies and certifies carbon credits.	Third-party, soil samples	10 years	$15 per carbon credit	None
ESMC	None	Crop and rangeland	Ag practices referenced in NRCS standards	Own credit and assets based on soil samples, remote sensing, and a proprietary model.	Third-party, site visits, remote sensing	10 years	N/A	None
Gradable	250 acres	Grain production	Minimal or no-till, cover crops, diversifying crop rotation, reducing nitrogen application.	Own credit generation based on soil samples, remote sensing, and a proprietary model.	Third-party, remoting sensing	5 years	Fixed price floor at $20/carbon credit	Credit for practices up to 2 years prior to joining.
Indigo Ag	150 acres per field	Field crops, excluding rice and perennials	Reduced tillage, cover crops, diversifying crop rotation, reducing nitrogen application.	Issued by Verra	Third-party, site visits, evidence checks, registry-approved methodology	5 years	$15 but subject to market conditions	Credit for practices up to 2 years prior to joining.
Nori	1,000 acres	A large variety of row crop/hay/grass and orchard/vineyard crops	Reduced tillage, cover crops, diversifying or expanding crop rotation, shifting to perennials, changing fertilizer to organic.	Uses Greenhouse Gas Implementation Tool to measure soil organic carbon stock change.	Third-party, site visits, evidence checks	10 years	One NRT token based on market conditions	Credit for practices up to 5 years prior to joining.
Nutrien (pilot)	None	Corn, wheat, barley, sweet potato, dairy	No or low till	Under development	Under development	1 - 3 years	$10-20 per ton of carbon removed	None
Soil & Water Outcomes Fund	None	All crops	No-till, cover crops, land retirement, conversion to pasture, and extended rotations.	Outcomes and payments are estimated using the COMET Farm and Nutrient Tracking Tool, soil and water testing.	Field visits, remote sensing	1 year	Up to $40 per acre per year	None
TruTerra	2.5 acres	Corn, soybeans, cotton, winter wheat	Reduced tillage, cover crops, diversifying or expanding crop rotation, shifting to perennials, N management.	Soil samples, carbon modeling	Third-party	20 years*	Based on market conditions	Credit for practices up to 5 years prior to joining.

Source: Plastina & Wongpiyabovorn, 2021

**TruTerra has recently reduced their contract amount from 20 years to 5 years (TruTerra, 2022). This brings the average overall contract length from 7 years to 6 years.*

Carbon Market Challenges

Farmers face multiple constraints to participating in VCMs including: a lack of standardization, additionality, perverse incentives, pricing incentives and farmer risk, leakage, and infrastructure challenges. In the section below we define and describe each challenge as it relates to agriculture carbon markets.

Lack of Standardization

VCMs are currently lacking uniform standards, transparency, and reliability (Mendelsohn et al., 2021). The current and emerging agricultural VCMs could be considered a group of coexisting programs with different rules, incentives, and penalties, rather than a cohesive market with set standards and regulations (Plastina & Wongpiyabovorn, 2021). The lack of standardization makes it difficult to establish baselines for benchmarking purposes. Determining a baseline is often crucial to ensure farmers receive a payout (McFarland, 2010).

With minimal regulation in place, companies can sell credits for carbon reduction efforts they would have done anyway (Mendelsohn et al., 2021). The challenge of regulation is compounded since most VCMs intersect with multiple state and regional regulatory efforts (Bayer, n.d.). There is a current private-sector task force in place to help set the standards for VCMs, but they are centered around specific projects and not a company or the industry as a whole (Mendelsohn et al., 2021).

Additionality

Additionality is the principle that carbon markets should incentivize activities that would not occur under "business-as-usual" conditions (Schulte & Jordahl, 2022). In order for a carbon credit to be generated, it must provide additional carbon reduction or sequestration above and beyond an established baseline. However, it can be difficult to establish a “business as usual” baseline (Mendelsohn et al., 2021). If farmers have previously adopted certain climate-smart practices, those practices are counted within their baseline. This can mean they are ineligible to participate in certain VCM programs or expected to implement additional practices to qualify. A Purdue University study found that nearly all carbon markets seek to enroll farmers who were not previously using carbon sequestering efforts for “new” carbon (Thompson et al., 2021). This means that farmers who are already implementing climate-friendly practices such as no-till and cover crops are ineligible to receive payments for carbon sequestration (Thompson et al., 2021). Effectively, additionality can punish early-adopting climate-smart farmers by making it harder to qualify for or receive financial compensation.

Perverse Incentives

A perverse incentive occurs when a result is produced that directly opposes the original intention of a program. In the case of VCMs, perverse incentives can ultimately cause worse environmental outcomes (Gordon et al., 2015). They create an undesirable and unintended consequence; particularly one that does not result in the further reduction of emissions or carbon sequestration. This can happen through intentional manipulation of a farm’s baseline or the delay of climate-smart practice implementation. An example of a perverse incentive is when the need to maximize revenue from carbon credits also incentivizes a net increase in CO_2 emissions (Wang et al., 2017). Another example is when participation in non-incentivized conservation practices decreases due to farmers prioritizing the implementation of other incentivized

practices that may not be as effective in reducing emissions (Gordon et al., 2015). Farmers have been found cutting corners to maximize profits and finding ways to incorrectly measure their carbon emissions, negating the original intent of the carbon market itself (Hertel, 2021).

Pricing Incentives and Farmer Risk

The payment structures of the marketplace are a contributing factor in participation and climate-smart practice adoption. While VCMs have grown, the cost of carbon has decreased because supply has far exceeded demand. The national cost of carbon has dropped from $7 per ton in 2008, to $3 per ton in 2019 (Blaufelder et al., 2020). This impacts VCMs because it decreases the financial incentive to further reduce emissions and sequester carbon. There is also no guarantee that VCM contracts will be renewed or that carbon will be sequestered, meaning farmers may invest capital in practice adoption that will never be reimbursed (Maixner, 2020).

Farming is an industry where the bottom line from year to year is variable and dependent upon several different factors. With any new practice, farmers are vulnerable to making mistakes that may negatively impact both their yields and their profits. If there are not adequate incentives in place to off-set the risk of implementing climate-smart practices, it could be difficult for farmers to do so voluntarily (Sellars et al, 2021). For these reasons, it is possible to see that inadequate pricing incentives and financial risk incurred by the farmer may be a barrier to participation (Maixner, 2020).

Leakage

Leakage occurs when carbon reduction measures taken in one place lead to carbon emissions in another. The Environmental Defense Fund suggests, “Leakage results when GHG emissions increase outside of the project area as a result of project activities” (Oldfield et al., 2021). For example, carbon reductions upstream may increase downstream emissions within the same industry. In relation to VCMs, leakage can occur when shifting crop production to other lands to compensate for yield reductions (Oldfield et al., 2021). Leakage can make it difficult to account for and measure long-term carbon sequestration because validating that sequestration requires the scientific means to prove more carbon is being held due to specific practices within the scope of a particular project (Ontl & Schulte, 2012). Leakage must also be considered along the continuum of time. Currently, carbon credit protocols vary in regard to how long the carbon must stay sequestered. This is known as ‘permanence,’ an alternative challenge closely linked to leakage (Oldfield et al., 2021).

Infrastructure

In addition to these challenges, there are other less concrete infrastructure-related challenges to consider. In order to understand these we must examine the entire agricultural supply chain. Implementing new climate-smart farming practices often requires new supplies such as seeds for cover cropping or different equipment for alternative tillage methods. Investing in supplies and equipment requires financial capital on behalf of the farmer (Myers, 2021). Accessibility to equipment share programs could provide farmers the opportunity to test certain practices, but these opportunities are also limited (Hopkins, 2015). There are many infrastructure-related barriers that farmers, and the industry at large, face when it comes to implementing climate-smart practices at scale.

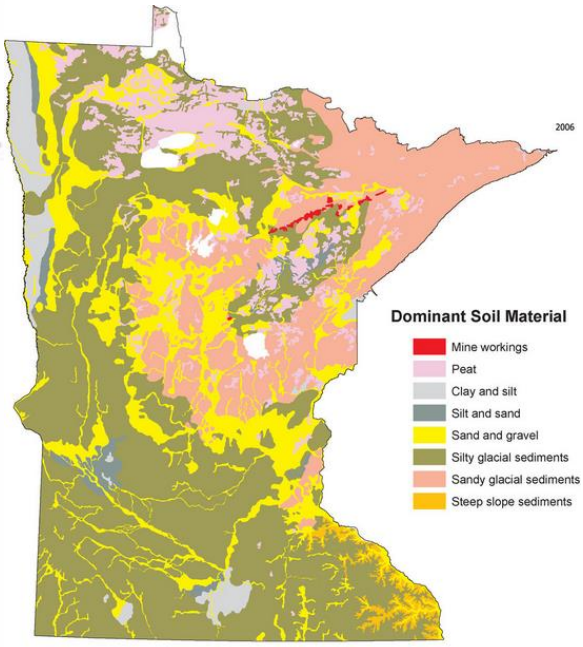
Emerging Carbon Markets in Minnesota

VCMs in Minnesota are still forming and face the challenges highlighted above. Due to this recent emergence, there is limited information available on farmer participation in Minnesota-specific VCMs. However, it should be noted that Minnesota is an ecologically diverse state with many different biomes and soil types (as depicted in Figures 4 and 5), which makes standardized practices to reduce uncertainties significantly challenging to address (Sagor, 2018). That ecological variability underpins agriculture and climate-smart farming practice adoption state-wide. It must also be taken into consideration by the different agencies and programs highlighted below.

Figure 4. Biomes of Minnesota

Source: Sagor, 2018

Figure 5. Dominant Soil Types of Minnesota



Source: Minnesota Geological Survey, 2006

Government Actors

The Minnesota Department of Agriculture (MDA) is the state agency best equipped to engage with agricultural carbon markets. However, due to the interrelated nature of the farming industry and climate-smart practices, they must also engage with an array of agencies responsible for a broad spectrum of natural resources and management practices. MDA is currently working to meet the state and nation's climate goals by assisting producers with current and future practices to reduce emissions and mitigate climate impacts (Petersen, 2021). Additional key players include the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Board of Water & Soil Resources (BWSR), as well as Soil and Water Conservation Districts (SWCDs). USDA is the federal government's agricultural division responsible for developing and implementing laws related to farming, forestry, food, and rural economic development. NRCS is a division within the USDA designed to work with farmers, ranchers, and communities to protect natural resources on private lands. BWSR is a Minnesota state agency designed to work with the many SWCDs across the state of Minnesota to conserve soil, water, and natural resources.

All of these agencies provide and oversee various programs, services, and funding opportunities that directly or indirectly impact carbon markets and climate-smart practice adoption. In regard to regulatory authority, MDA has regulatory power over pesticide usage, however, it does not have regulatory authority over VCMs or climate-smart practices within the state. To address this, MDA is currently recommending the USDA create system-wide standards and define who has authority over carbon markets (Petersen, 2021).

MDA Program Overview

MDA's ***Minnesota Agriculture Water Quality Certification Program*** (MAWQCP) has the most programmatic overlap with the climate-smart practices used in VCMs because many of the conservation practices intended for water quality are also climate-smart. MAWQCP is a voluntary opportunity for farmers and agricultural landowners to implement conservation practices that protect water resources. Farmers who implement and maintain approved farm management practices are certified and obtain regulatory certainty for a period of ten years (MDA, n.d.c). Participants are also provided with technical and financial assistance to implement practices that promote water quality. MAWQCP also provides a Farm Business Management (FBM) Scholarship that teaches water quality certified producers business management strategies that lead to profitable and competitive farming operations (MDA, n.d.c). In addition to MAWQCP, MDA offers other financial assistance grants such as the Agricultural, Growth, Research and Innovation (AGRI) grant. This grant aims to increase productivity, improve efficiency, and assist the development of agricultural products (MDA, n.d.b). They also offer business development loans as well as Agricultural Best Management Practice (MDA, n.d.a) loans for best management practices.

Additional Minnesota Programs Overview

Beyond MDA, two programs in Minnesota are worth noting in regards to climate-smart practices and carbon markets:

- The Ecosystem Services Market Consortium (ESMC) and The Nature Conservancy's (TNC) 2020 pilot project provides financial incentives for farmers to implement carbon sequestration efforts (The Nature Conservancy, 2020).
- Forever Green, a University of Minnesota research program, is also developing and improving winter-hardy annual and perennial crops that protect soil and water while also driving economic opportunities for growers (University of Minnesota, n.d.).

Key Informant Interviews

Methodology and Overview

We conducted virtual one-on-one interviews with 26 key informants to gain a deeper understanding of agricultural carbon markets and climate-smart practice adoption in Minnesota. Interviewees shared insights around barriers for climate-smart practice adoption, potential positive and negative impacts of carbon markets, and possible solutions for increasing participation, including ideas for how MDA should be involved. Key themes are included in the sections below.

The key informants were suggested by MDA and represent various positions in the sector including farmers, farmer representatives, federal and state agencies, for-profit and conservation organizations, and academic institutions. However, we found that many interviewees were a part of multiple groups. As such, we did not separate findings out by role. It should also be noted that interviewees were selected based on their knowledge of carbon markets, so cannot be considered representative of the broader farming community. The majority of interviewees were Caucasian and male-presenting, which is also a limitation to the interview findings. We provide a more detailed description of our interview methodology in Appendix B.

Barriers for Implementing Climate-Smart Practices

Our interviews revealed a consistent pattern of obstacles to implementing climate-smart practices. These largely included financial barriers, lack of education, uncertainty or risk, environmental variability, and other structural issues that make it hard to participate in climate-smart practices.

Financial Barriers

Participating in climate-smart practices can have a positive financial impact in the long term, however, it requires substantial upfront capital. Financial concerns, in particular upfront costs, were most frequently mentioned, with more than half of the interviewees noting these concerns.

Within those upfront financial costs, equipment costs were most commonly discussed. Nearly half of the interviewees noted equipment costs as a barrier. Equipment to convert to no-till, strip-till, or vertical tilling systems was a particular concern. Some interviewees also noted equipment costs or upfront costs for putting in cover crops, including machinery, seed, and fertilizer costs. A couple of interviewees noted that in particular, these are barriers for small farmers who may not be able to afford upfront costs or do not have access to the same capital as larger farmers.

Profitability concerns were another key financial barrier. As one farmer noted, farmers need to provide for their families and have to be concerned about their financial bottom line. The cost-benefit ratio has to work out in the farmer's favor to implement practices. Within that, there are more nuanced concerns around yield, financial risk, capital costs, the cost-effectiveness of input products, ability to grow the business, and market viability of newer climate-smart practices or crops like hemp. One interviewee noted that in times of profitability, farmers will be willing to accept more risk. Currently, we are in a time of profitability for farming, but we are not always. The economic viability of the practice has to be sustained in the long run, even in non-profitable years where farmers are more risk-averse.

Educational Barriers

Most interviewees noted that switching to climate-smart practices requires educating farmers about the practices. Interviewees discussed a big learning curve related to new practice adoption since farmers have not done the practice before. There are new pieces of equipment, management practices, and implementation steps. It also potentially requires you to go against what you had previously been taught. One interviewee noted that they are asking farmers to make a change that is bigger than any other changes they have made in their own life, so it is difficult. Participating in programs also has a learning curve around understanding requirements and eligibility. All of these factors make technical assistance important. This requires mentors and guides, which a couple of interviewees noted are lacking.

Multiple interviewees also felt there is not enough science or research to support the carbon benefits claims from climate-smart practices, especially around reduced tilling and cover cropping. The capacity for carbon sequestration is unclear, which is of particular concern when entering contracts for carbon markets that are predicated on a certain amount of carbon being sequestered. One person mentioned the University of Minnesota Extension could help with education around research and science. However, another mentioned that even if there is new research coming out, it takes decades to prove true carbon sequestration, and most studies have been short-term, so the findings are shaky.

Uncertainty and Risk

Over half of the interviewees mentioned uncertainty and risk as a barrier. Implementing new practices inherently comes with risk; if farmers have not done them before, they do not know how they will perform on specific fields. Carbon sequestration also varies from field to field, by soil type, and by weather conditions, which adds to the uncertainty around carbon sequestration potential. One of the biggest risks mentioned was a potential reduction in yields. One farmer noted that there is a general acknowledgment that farmers may see reduced yields to start as the soil adjusts because there are reduced or different inputs. This makes farmers nervous and puts their financial stability at risk from an input, machinery, and yield standpoint. There are also management risks as implementing new practices could change the way the farm works. Additionally, how carbon sequestration is measured varies, and farmers are nervous about whether their potential carbon sequestration will be realized in practice. They are therefore apprehensive about how that might affect contracts or their participation in carbon markets.

Several interviewees noted that given the risks new practices bring, farmers are reluctant to change their practices. One farmer noted the common adage “if it ain’t broke, why fix it.” Shifting the mentality of farmers toward changing practices provides a deeper barrier for implementing climate-smart practices.

Multiple interviewees also noted the social risk of changing practices. Farmers may face peer pressure or anxiety around their practices. One interviewee noted that early adopters are going to try new things, but most people need a buddy who is already doing it. Farmers may also make changes when there is a natural farm transition, like during farm succession or when new equipment is needed. Another interviewee noted that farmers pay attention to what others are doing, and may even try to hide practices if they are seen as being too “wild.” There’s a cultural shift that needs to happen to make the practices more widely accepted and adopted.

Environmental Variability

Another common barrier was environmental variability. Interviewees noted that soil types and landscapes vary widely across the state, which affects farming practices. There was particular concern about cover crop timing and the ability to effectively grow cover crops and sequester carbon in Minnesota's short growing season. Cover crop success may also vary across soil types and benefits may not be seen immediately. One interviewee noted, "The challenge is if they do not see an immediate result, then they'll say it doesn't work." Similarly, a farmer noted that they had tried cover crops and they did not work unless they were in the field before the end of August, which was a challenge.

Other Structural Issues

In addition to the above issues, at least two interviewees each noted that land tenure, crop insurance, and a lack of supply chain for alternative crops hinder the adoption of practices. A large portion of farms are rented in Minnesota; if you do not own the land it can be harder to participate. One interviewee discussed that for renters, large investments or changes may not be worth it because the long-term time horizon of benefits may not benefit the renter. People also noted that the current system is set up to support corn and soybeans, which is reinforced by the crop insurance system. People doing cover crops have to be careful about coming into conflict with crop insurance. One interviewee noted that it can be more profitable to continue to plant an annual crop on land that is not suitable but collect insurance. There is also a lack of markets to support alternative crops such as short-season crops, small grain, wheat, and hemp. One person also noted potential supply chain issues with machinery and other inputs.

Additionally, people noted structural concerns within the key stakeholders of the agricultural system. Several people mentioned the need to work with trusted players in the community to increase adoption. For some, this may mean getting agronomists on board, for others, this means working with organizations that interact with smaller farm operations or farmers who are Black, Indigenous, and people of color (BIPOC). One person pointed out a potential conflict of interest where the farmer may be getting advice from the same person who sells the products, which could be an issue. Another person noted that people do not trust the government, which is worth considering when developing solutions and roles for MDA.

Carbon Market Awareness and Impacts

As previously noted, agricultural carbon markets are emerging and their impacts are not well-known in Minnesota. Thus, we did not expect stakeholders to have a comprehensive understanding of carbon market impacts and challenges. However, most interviewees had perspectives and opinions on carbon market potential, as well as a pulse on how farmers were perceiving carbon markets.

Awareness of Carbon Markets

We did not originally include a question explicitly asking about farmers' awareness of carbon markets, but we did add a question after conducting several interviews. Most people felt there was a high level of awareness around carbon markets, but farmers were skeptical and cautious to participate. However, it is important to note that our interview sample reflects people who may know more about carbon markets, so our assessment of awareness may be skewed. Multiple interviewees mentioned that farmers know carbon markets exist and are getting solicited by carbon market actors. They also noted that farmers may be curious or interested, but that there is still skepticism. One interviewee felt that there was little to no awareness of

carbon markets within smaller farms and BIPOC farmers who may be left out of the opportunities carbon markets provide. This is an area to investigate further.

Potential Benefits

Most interviewees noted some skepticism around carbon markets, but many also saw potential benefits. In the best-case scenario, carbon markets could increase the adoption of climate-smart and environmentally beneficial practices. One interviewee noted they had been involved with case studies of farmers who had implemented climate-smart practices, and several farmers said they were paid to put in cover crops in a certain year. They saw soil health and other ecosystem benefits and therefore continued the practices.

Others noted that carbon markets are creating a buzz around climate-smart practices, and this conversation can increase education, build peer pressure, normalize practices, and help shift the broader mindset to support conservation and stewardship. There is also a community-building aspect where early adopters network and talk about how practices are working. One interviewee also noted being able to bring agronomists and ag retailers into the conversation, which could be particularly helpful as they help farmers collect data. They could potentially help compile or share baseline data for carbon market verification. Similarly, a couple of interviewees noted that having carbon markets share on-farm verification data with farmers can be a benefit to the farmer. Based on our understanding from the literature review, this is not something that happens in every carbon market as it depends on the type of verification. Soil carbon is a resource, and being able to track and look at trends can help farmers better understand the impact of the practices. In general, farmers also take a lot of pride in their work. Multiple interviewees noted that farmers want to be a part of the solution, and carbon markets could be a way to show they are doing work for the greater good.

Interviewees also noted that farmers are interested in the financial opportunity carbon markets could provide. While the upfront capital may be high, people may see lowered diesel bills or input costs and increased soil health, which can increase economic viability for the farm in the long term. The practices themselves can therefore be profitable without the carbon market incentive. However, multiple interviewees felt current financial incentives may be the boost or incentive needed to push already-interested farmers over the edge to adopt new practices. They also mentioned that currently the incentives are so low that carbon markets are not seen as the main driver for changing practices, however if the benefit amount increases, that could change.

Carbon Market Skepticism and Challenges

Farmers are skeptical of carbon markets, and several interviewees noted this skepticism was justified or healthy. The skepticism manifested in several ways. First, there was concern about who reaps the benefits of carbon markets. Farmers are worried the companies who purchase credits would both be the primary beneficiaries and be allowed to continue polluting. Carbon markets could also be another mechanism that continues to concentrate wealth in large companies, and the farmer gets the proverbial short end of the stick. Relatedly, one interviewee noted that the companies get the PR for participating in carbon markets, and thus get all the credit.

Farmers are also worried that companies will be paying to sequester carbon, but the actual carbon sequestration will not come to fruition. Interviewees noted that carbon sequestration is challenging to measure, and without strong science showing the carbon sequestration potential, there will be hesitancy. They discussed that each farm, and even each field, is different. Carbon sequestration potential varies by soil

type, weather, and other factors, so a one-size-fits-all approach is challenging. One interviewee discussed that while some climate-smart practices may temporarily sequester carbon, unless they are doing perennial planting, the next season the carbon may be released again. This means that participating in carbon markets could be doing a disservice to the public by not sequestering the assumed emissions.

Given the challenge of measuring carbon sequestration, multiple interviewees suggested alternative markets based on more measurable ecosystem services. Similarly, the majority of interviewees noted that you need to look at practices and benefits holistically. The same climate-smart practices have other benefits, like water quality and soil health. These other benefits may be more tangible to measure, easy to understand and have annual benefits that could eliminate some of the concerns around additionality in a broader ecosystem services market.

The uncertainty around actual carbon sequestration further complicates participation, and farmers are hesitant to engage in contracts based on sequestration. They do not want to be responsible if, down the road, they find out the actual sequestration amount is not the presumed amount. The long time horizon for a contract was also a primary concern, especially for older farmers who may be thinking about farm transitions to the next generation or to renters. A couple of interviewees also discussed concerns around data privacy and who owns the data about their farm. They are worried about data mining and how their data may get used, as well as potentially getting flagged for something less desirable, reducing the market viability of their products. Other contract concerns include: the lack of flexibility; variation of contract terms; the need for "act of God" clauses when a weather event may preclude the farmer from achieving desired reductions; the amount of acreage they are committing; not wanting to lock themselves into a contract; and the fact that they may not be able to take advantage of other opportunities, especially as people are waiting to see what is included in the 2023 Farm Bill.

This last point of exclusion from future program eligibility was a big concern. As noted in the literature review, farmers can typically only get credits if they are above and beyond what would have happened under their current practices. Thus, if they switch to doing climate-smart practices now, they usually cannot count those benefits again in the future. Many interviewees discussed that farmers want to wait and see what happens with the markets before jumping in.

This was primarily discussed alongside the point that the payment for carbon credits is quite low. This sentiment included both that the benefits farmers are providing are undervalued, especially compared to the benefits companies receive for purchasing carbon credits, and that the amount offered is very minimal compared to the amount needed to change practices. For example, one interviewee noted that a $15/acre credit is barely enough to cover running a drill across a field. People also noted that the minimal amount might not be worth the extra time to participate. To encourage participation, prices need to go up. This means that people may delay participation in climate-smart practices as they believe prices will increase, and they want to see how the dust settles in the "wild west" of carbon markets.

Given the low incentive amount, some people also felt that stopping payments from a carbon market would not have a major impact on the continuation of climate-smart practices. They felt farmers would see other benefits, like reduced fuel costs or water quality benefits, and the capital costs of switching practices or management are too high to switch back. However, others felt that stopping carbon payments would directly impact adoption of practices, and people would stop doing practices once payments stopped.

Additionality and Perverse Incentives

Interviewees noted additionality as a challenge and generally felt some sort of reward or recognition should be given to early adopters. One method of flexing current terms to reward early adopters would be to have a lookback period of one to five years. This would allow for a bridge payment so newer adopters can still get credit for taking the risk to implement these practices. This does happen in some carbon markets, however, this is unusual. Interviewees also felt that some sort of maintenance or stewardship payment could be appropriate, especially for people who have been doing the practices for a longer period of time. However, a couple of interviewees also noted that no additional support is needed for farmers who have already converted to climate-smart practices. They felt these farmers have already made the switch and likely are realizing the benefits.

MDA was also interested in exploring how prevalent perverse incentives were with carbon markets. They were curious to hear if farmers who were previously doing climate-smart practices may stop doing the practices and restart practices so they could then participate in the carbon markets and receive credit. Interviewees mentioned this may happen in rare instances, but for the most part, once farmers switched to doing climate-smart practices, they will continue doing them longer-term. Interviewees said that the people already doing climate-smart practices, the early adopters, are likely doing them because they believe in them and are seeing other benefits. The costs for implementing the practices and then reverting back to conventional practices are also high. Some interviewers did note that this may change if carbon pricing increases significantly. Waiting to adopt climate-smart practices to see how the carbon markets shake out was suggested as a more likely and more widespread scenario. This is another type of perverse incentive, but not as severe.

Types of Support and Potential Solutions

Given the barriers and challenges, interviewees suggested different types of support needed and potential solutions. Interviewees were asked specifically about MDA's role in providing support, which provided additional guidance on potential roles for other governmental entities on national (USDA) and local (SWCDs) scales. We did not evaluate whether these are appropriate roles for these government entities, but provide the suggestions described by interviewees.

Government Involvement

We asked interviewees explicitly about the role that MDA could or should play in overcoming challenges with carbon markets or expanding climate-smart practice participation. Interviewees had a myriad of ideas for MDA's potential role, which are highlighted within the solutions presented below. Throughout the conversations, there were also a number of perspectives on overall government involvement with carbon markets and climate-smart practices. Some interviewees felt strongly that carbon markets should remain voluntary, while a couple others noted that voluntary programs have more limited reach and you may need to force participation. Interviewees from both viewpoints noted the need for flexibility for farmers and that a one-size-fits-all approach may not be appropriate. Interviewees also mentioned that regulatory certainty provided in exchange for participating in the MAWQCP was attractive and could be emulated with carbon markets.

Several interviewees also mentioned that they would prefer no government involvement with carbon markets. Several noted a preference for free-market creation and correction being driven by customers and

companies. One interviewee felt problems were because of the government and noted that the government created the corn market, and now they are trying to adopt conservation practices to go against corn. Thus, the government is trying to solve a government-created problem. Some interviewers, however, advocated for market development, indicating it was needed both for carbon markets and for other climate-smart crops (like hemp or kernza) or sustainable byproducts. Governmental roles could therefore range from a more direct market intervention to an advocacy role for market development or farmers. The diverse perspectives on governmental response should be taken into consideration when designing MDA approaches, noting that some actions could be more heavy-handed and some may have a lighter touch to appease multiple viewpoints.

Several interviewees also noted that MDA is currently doing as much as they can given their resources, and thus did not recommend expanding their role. Some interviewees felt things like standards, regulations, and enforcement should be left to federal entities, while others noted that private industry could navigate it. One interviewee noted that MDA does not have the resources or influence over large corporations, and therefore federal entities would need to be leading efforts.

Financial and Equipment Support

Given the prominence of financial barriers for converting to climate-smart practices or participating in carbon markets, interviewees suggested a variety of financial mechanisms to support farmers. The most commonly suggested option was to provide financial incentives for people to do climate-smart practices. Financial incentives could include increasing current payments, however, interviewees also identified this as an opportunity for MDA or USDA to offer financial incentives outside of a carbon market scheme. This could be attached to existing service payment schemes or through a new program created for this purpose. ***Again, paying people for ecosystem services other than carbon sequestration was a key potential solution***. Interviewees also suggested paying early adopters of climate-smart practices so they are not punished for implementing practices prior to current payment schemes. A couple of interviewees also noted providing funding to farmer mentors to support the training of other farmers around practice implementation. Interviewees saw these payments as a way to reduce financial risk for farmers and noted the need to minimize risk for farmers more generally.

Many interviewees also noted the need for additional innovation and research, which in turn needs additional funding. This was most often generally mentioned as “we need additional research and innovation.” However, interviewees also suggested specific research agendas related to verifying the effectiveness of climate-smart practices like cover crops, research into additional crops like hemp, and market development. Some saw this as an area in which MDA could assist.

Finally, as capital and access to equipment is a large barrier, providing financial assistance to help overcome that hurdle would be beneficial. This could be in the form of grant or loan programs through MDA or another entity. One interviewee noted that grant programs may be favored over loan programs. Multiple interviewees suggested that creating an equipment share or rental program could be beneficial for farmers to test or begin implementing practices. SWCDs were identified as a good partner for pursuing the implementation of an equipment rental or trial program.

Education and Technical Assistance

The majority of interviewees discussed education and technical assistance as key to helping farmers understand, adopt, and continue doing climate-smart practices. Most commonly, this included sharing information about the science and benefits of implementing practices. This may also entail doing additional research to verify effectiveness. This educational role could be played or supported by MDA. Information desired included on-farm examples, proof-of-concepts, and clear data. Information to highlight includes: carbon sequestration, other environmental benefits like water quality and soil health, and financial benefits.

Interviewees also discussed the need for education around carbon markets and navigating the processes involved. Most often, this navigator role was discussed as something MDA could fulfill. This role could involve reviewing contracts for fairness and accountability, creating a guide for farmers on carbon market options and what farmers should look for before entering into an agreement, and generally serving as an unbiased advisor.

Network Building

The majority of interviewees mentioned network building as a way to garner support and increase practice adoption. ***In particular, most interviewees noted farmer-to-farmer or peer-to-peer sharing as being invaluable.*** Hearing from a farmer who has already adopted these practices, or has participated in VCM programs, can highlight successes and how they overcame challenges, give additional details about implementation and results, and break down potential stigma, leading to practice changes. Some interviewees also discussed bringing agronomists, advisors, and ag retailers into the fold as they are often a trusted source of information for farmers. However, one interviewee noted the need to move away from having the seed salesman or fertilizer salesman as the primary source of information because their best interest is not reducing inputs. Farmer-to-farmer sharing can be a less-biased mechanism. Some noted that MDA could play the role in bringing farmers together; others noted that other farmer groups, SWCDs, and NRCS initiatives could be a good place to network and build relationships. Interviewees also noted that MDA could serve as a partner with farmer groups and other government entities including: NRCS, USDA, BWSR, local government, SWCDs, Drinking Water Supply Management Area (DWSMA) managers, and the legislature.

Carbon Market Standardization and Transparency

Carbon market platforms or companies like Nori, Bayer, etc. have different ways of operating and crediting. They include different agricultural practices for credits, the way of measuring practice effectiveness is different, and incentive or payment structures vary, as do contracts, among other things. ***The need to create standards across markets was a salient theme among interviewees.*** Most suggested standards should be set at a federal level.

Multiple interviewees highlighted the need for standardization of carbon sequestration measurement. This was coupled with the need to actually verify carbon sequestration at the farm level. One interviewee mentioned that this would require additional soil testing per acre, but that testing by acre could be more expensive and may eventually create a disincentive for joining carbon markets. However, this interviewee noted that new technology, like satellite imagery, could help alleviate that cost burden and still verify carbon sequestration.

Interviewees also noted the need for transparency and clear expectations around carbon market participation. This includes clarifying terms and language, better understanding the science, being clear about what happens if the amount of carbon contracted for is not sequestered, and being able to understand contract terms and data privacy, etc. Another major theme was around corporate accountability and fairness in regulation. Interviewees wanted to make sure that farmers get their fair share of carbon payments and that private industry or carbon market middlemen are not getting the bigger benefit. They also want to make sure that data and proprietary business information, especially for farmers, is protected. One interviewee noted that MDA's role could be to prevent predatory practices to make sure things are fairly organized. In a similar vein, interviewees wanted to make sure that companies were also held accountable for their emissions and that emissions reduction plans are put in place to make a change and avoid greenwashing.

Ultimately, interviewees felt that ***flexibility*** for farmers in carbon markets is key. This could include different approaches for different landscapes/parts of the state, flexibility in practices, ability to adapt to changing conditions like weather events, flexibility in the size of farms that can take advantage of opportunities, allowing farmers to claim additional ecosystem services benefits, and regulatory flexibility if they participate in carbon markets. As one interviewee said, the carbon markets need to be set up in a way that allows farmers to innovate and be freer in their decision-making. Another said that "if you give them a goal to strive for, and it is a voluntary thing, farmers will exceed your expectations, but if you have restrictions and do not allow much for creativity, you will not get the best results." Interviewees also noted the need for pilot programs for carbon markets or the flexibility to put a small amount of land under climate-smart practices.

Structural Changes

Some interviewees discussed the need for broader agricultural reform beyond carbon markets. One interviewee was skeptical of the ability to achieve goals through corn and soybeans. They felt that "tweaking" the current system for carbon capture will not work and there need to be new policies and investments to sequester carbon. Other interviewees noted the strength of the ag commodity crops like corn, soybeans, and livestock, and the need to revisit this agenda around agriculture. A couple of interviewees also noted the need for cultural shifts and social support. One reiterated that farmers are highly influenced by what people in their communities are doing and suggested a marketing push to overcome peer pressure barriers. One discussed that despite the strong traditional commodity crop market, economics are starting to shift; for example, perennial green crops are becoming popular and consumers are more aware of other solutions. Finally, one interviewee noted challenges with RMA and insurance, which can stifle innovation.

As many interviewees noted, there are numerous benefits to these practices beyond carbon sequestration, and there is a need to look system-wide to holistically capture benefits. One notable solution would be to incorporate things like water quality or soil health credits into the models or create a different system for crediting these benefits. Adding these benefits could reward farmers for the full suite of public benefits they provide through adopting these practices. They are also more measurable and easy to understand, see, and target. One interviewee also mentioned the need to center the farmer and align messaging around environmental goals and practices. Another holistic dimension was considering time horizons for agricultural change. Interviewees noted both that benefits continue beyond an annual basis, and that it could take multiple decades to see substantial climate benefits.

Support for Specific Groups

To broaden the reach for climate-smart practice adoption, interviewees suggested several specific groups to support or engage, in addition to the agency partnerships previously mentioned. Most commonly, this included farmer-centric associations or programs. People suggested supporting or working with farmer co-ops, soil health groups, sustainable agriculture groups, commodity organizations like Minnesota Corn Growers, and Minnesota Farmers Union. A couple of interviewees specifically called out supporting marginalized or traditionally underrepresented groups, including supporting BIPOC farmers as well as smaller or midsize farming operations. It is also worth noting that our interviewees were largely white males, and this may be a more salient theme among a more diverse group of stakeholders.

Program Leverage and Examples

While most interviewees noted carbon markets elsewhere had not successfully overcome challenges, they mentioned several carbon market or ecosystem service market examples that they felt Minnesota or the US in general could learn from. These markets, and the highlighted points from interviewers, include:

- Chicago Carbon Exchange - seen by multiple interviewees as something that did not work well
- EU carbon markets - one suggested prices here were too low
- Australian carbon markets - one suggested prices here were too high
- Canadian carbon markets - one suggested British Columbia as a place where prices were too high
- TruTerra - positive lookback period and data gathering practices
- Grassroots Carbon - verification based on actual carbon sequestration, with soil testing paid by the farmer where the cost is not paid upfront but comes out of carbon payment
- Iowa and Illinois - looking beyond carbon and including water quality, also Iowa success in cover crop policy
- California Cap-and-Trade - recently incorporated soil carbon and has cap on emissions for industrial/power sector
- Stearns County - water quality trading market pilot
- Utility carbon market programs and their evolution with carbon markets - especially the concept of a circuit breaker where the market can correct if prices go too high or low
- MPCA water trading program with wastewater treatment plants that have discharge limits and can purchase credits or upgrade equipment

For more context around the Chicago Carbon Exchange and California Cap-and-Trade market development, please see Appendix C.

In addition, there were several programs that interviewees mentioned could be expanded, leveraged, or modeled as potential solutions to carbon market challenges. The MAWQCP was the most commonly mentioned program. This could be in part because several interviewees sat on the MAWQCP Advisory Committee, however, this was mentioned also by those outside of that committee. Interviewees liked that this program is voluntary, has clear practices and changes associated, provides flexibility and allows the farmer to drive decisions, provides regulatory certainty, relies on third-party/public certifiers rather than private, and does a good job of connecting farmers with resources. Interviewees mentioned overlap with practices used for this program and those used for carbon markets, and they suggested this program could be expanded as a ramp-up or bridge to carbon markets. Ideas for bridging programs included an automatic qualification for carbon markets if MAWQCP certified, data sharing across programs, and potentially doubling up on credits or payments for water quality benefits.

Additional programs to potentially leverage or model include:

- RIPE Roadmap - pays for pre-existing ecosystem services
- EQIP - could stack EQIP payments with carbon payments
- Forever Green crops - continue funding and research
- Green America - focuses on water rather than carbon
- National Conservation Stewardship Program (CSP) - deals with additionality for people who have already adopted practices
- Clean Cars rule - has early action credits
- Clean Water Fund - utilizes a cost-share mechanism
- Farmer-to-farmer research programs

Other Potential Solutions

In addition to the broader themes, interviewees had suggestions for other solutions. Several interviewees noted solutions related to farmer protections and third-party involvement. This included: creating a state or federal insurance program if they fail to sequester carbon; determining and initiating protections, similar to the strong corporate farm law in place in Minnesota; or providing another way to help with risk mitigation. A couple of interviewees also noted aggregation of some kind. One interviewee talked about potentially having the USDA serve as a small farm aggregator to help smaller farms participate, and another talked about essentially having a carbon bank that would aggregate and hold credits from various sources and ensure they mean something. Another interviewee suggested having a third party complete logistics with carbon markets.

Interviewees also mentioned providing non-financial benefits. This was largely in the form of recognition and social support. As one interviewee noted, farmers are doing a great job and should be acknowledged. Another stated that farmers appreciate the recognition from peers. In terms of social support, one interviewee noted that farmers who are invested in these practices are often a part of a group and have buddies, like teams within an SWCD. This could be a place for MDA, SWCDs, or other local groups to step in and assist.

One interviewee suggested several options outside of crop systems, including taking land out of production through easements and looking more to forest carbon markets rather than crops. This interviewee also noted that more information about farmer receptiveness and attitudes would be helpful. Finally, one interviewee felt that setting goals for practice adoption, like a percent of adoption by year would be helpful.

Recommendations

Interviewees offered a wide range of suggestions, and after completing the analysis we created the following recommendations for MDA to support climate-smart practices and carbon markets. We have organized recommendations by finances and equipment, education and connection, and structural changes.

Finances and Equipment

1. **Offer financial support, especially for benefits outside of carbon markets** (e.g. water quality improvements, soil health improvements). This could apply to both new and existing practices. Additionally, it is important to consider ways to support mitigating risk for farmers.
2. **Create or expand loan/grant programs to fund equipment for climate-smart practices**. If possible, grant programs may be preferred. Also, work with SWCDs to provide equipment share or equipment trial programs.
3. **Advocate for carbon sequestration research/innovation.** MDA may be able to financially support research initiatives, or otherwise support this. It is especially important to continue research around the validity of practices for carbon sequestration potential. Additionally, while people often mentioned the benefits of free-market economies, there were some calls for trying to expand the market to support additional crop varieties or byproducts. MDA could thus participate in market development.

Education and Connection

4. **Provide education and technical assistance to farmers.** This can include disseminating research findings, providing successful farm examples or proof-of-concepts, working with farmers on how to implement practices, and otherwise helping with climate-smart practice adoption.
5. **Enhance partnerships with agencies and support network-building opportunities for farmer-to-farmer sharing and social support systems**. In particular, further enhance partnerships with NRCS, USDA, BWSR, local government, and SWCDs as well as looking for other partnerships. Work with SWCDs and NRCS to support farmer sharing and networking, and increase support to farmer-centric organizations, BIPOC farmers, and small-midsize farming operations.
6. **Provide guidance around carbon market participation, serving as a navigator for farmers**. This could include both a written guide and conversations with farmers, walking them through carbon market participation. Information should include what carbon markets exist, what to look for when participating, and how to navigate contracts.

Structural Changes

7. **Push for USDA or another federal entity to create standards for carbon markets and hold companies accountable**. Most felt MDA should not play the role of creating standards. Therefore, advocating for the standards may be the best role for MDA. This includes advocating for clear guidelines on what happens if farmers are not able to actualize their carbon market sequestration, putting safeguards in place for predatory practices, ensuring farmers are getting their fair share of benefits, and maintaining farmer flexibility among the standards.
8. **Leverage existing programs, especially MAWQCP**. This could include using MAWQCP as a bridge to carbon markets through data sharing or eligibility, using it as a dissemination platform for

educational resources, or using it to increase payments for other ecosystem services like water quality. Overall, support programs that focus on system-wide or other ecosystem service benefits.

9. **Create a way to broadly recognize farmers doing these practices**. Farmers should be acknowledged for the practices that benefit the greater good. This could be a certification along with MAWQCP or recognition through awards or other farming peer events.

Conclusion

Overall, there is heavy skepticism around carbon markets as they currently exist, especially around carbon sequestration science and the actual potential to drive climate-smart practice adoption. Focusing on an ecosystem services market model and the broader environmental impacts of implementing climate-smart practices, particularly soil health and water quality, may be a stronger path forward given scientific uncertainty and assumptions in current carbon markets (e.g. additionality, contracting, etc.). Expanding MAWQCP could be one route for MDA to increase practice adoption and focus on ecosystem services by adding incentives, creating a strong peer network, and disseminating research. While a broader focus on ecosystem services may be more prudent, if MDA does want to focus work around carbon markets specifically, pushing for clear standards and helping farmers navigate the process would be highly impactful for farmers. Regardless of MDA's relation to carbon markets, switching to climate-smart practices requires significant upfront capital and investment in equipment. Increasing equipment access for farmers to test climate-smart farming methods would be an additional high-impact route for MDA to pursue.

A broader switch to climate-smart practices will also require education and a larger social effort. The social hesitancy and the need for a community of peers are important to consider when encouraging adoption. Interviewees heavily emphasized farmer-to-farmer learning and the need for proving practices at a more localized level. MDA can facilitate this peer-to-peer learning and strategically design localized experimentation and demonstrations to reduce uncertainty and minimize farmer risk. Creating a strong social environment for climate-smart practice adoption will also require building trust and strong partnerships with organizations and individuals that farmers trust, like agronomists and ag retailers. Ultimately, this can help with the broader cultural shift and large-scale climate-smart practice adoption.

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Appendix

Appendix A: Interview Guide

Note:
After completing about 10 interviews, the interview guide was adjusted slightly from its original format. Question 3 was added in an attempt to gauge carbon market awareness in the farming community. Since adding an additional question lengthened the interview, several questions were deemed less essential if time constraints were present. Those questions are in gray.

Climate-Smart Agricultural Practices and Carbon Markets Interview

Background
Hi! My name is ____, and I'm a student at the U of M.

Thank you very much for your time and participating in this interview!

As we mentioned in our introduction email, we are working in collaboration with the Minnesota Department of Agriculture (MDA). They are interested in better understanding climate-smart practices and how agricultural carbon markets are influencing current or future agricultural ecosystem services and practices. Ultimately, we will use the findings from this research to provide recommendations to MDA on their potential role in addressing agricultural carbon markets, enhancing farmer participation, and advancing climate-smart practices in Minnesota.

Consent
Before we begin, I would like to go over a few key points.

You were selected for this interview because MDA thought you would have helpful insights related to *climate-smart practices, farmer motivations, and/or carbon markets.* We also recognize that carbon markets are still emerging, and we do not expect you to be an expert. Please feel free to speak openly, and let us know if you do not want to answer any questions.

This interview is voluntary and confidential. However, just so you are aware, while we will not use your name and/or title unless you approve this, it may still be possible for MDA to identify you based on the information you provide.

Is it ok for us to record this interview? The recording is only for our research team so we can go back and fill in notes in case we miss anything.

Yes / No

Are you comfortable with us using your name, title, and direct quotes to be used in any reporting with this project? If you agree, you can let us know if there are particular sections you would like us to refrain from attributing to you.

Yes / No

Do you have any questions, comments, or concerns before we begin?

Introduction

1. To start, could you briefly discuss your role and how you currently interact with climate-smart practices and/or carbon markets?

Climate-smart practices and carbon markets

2. What do you see as the biggest barriers for farmers to participate in climate-smart agricultural practices? By climate-smart agricultural practices, we mean things like no till, cover crops, conservation cover, perennial plantings, etc.
3. [ADDED] What is your perception of the farming community's interest in or awareness of current MN carbon markets?
4. How do you see agricultural carbon markets impacting the adoption or implementation of on-farm climate-smart practices?
    a. What are or could be the successes?
    b. What are or could be the challenges?
5. [if not already discussed] How do carbon markets work with farmers who are already doing climate-smart practices?
    a. How should carbon markets work with farmers who are already doing climate-smart practices?
    b. How much of an issue do you feel perverse incentives are? For example, a farmer reverting their pre-existing climate-smart practices to non-climate-smart practices to then be able to participate in the carbon markets?
    c. What are or could be some of the positive impacts of carbon markets that you notice regarding farmer behavior or participation?
    d. [cut for time if needed/seems less appropriate] What are or could be some of the negative impacts of carbon markets that you notice regarding farmer behavior or participation?
    e. How much of an issue do you feel stopping payments could be or is when it comes to climate-smart practice participation?
6. What kind of support do you think farmers need, if any, to continue doing pre-existing climate-smart practices?
    a. What kind of support do you think farmers need, if any, to begin climate-smart practices?

Policy or other solutions

7. Have you seen agricultural carbon markets, here or elsewhere, successfully overcome the challenges you have discussed? If so, how?
8. [cut for time if needed/seems less appropriate] Are there particular policy interventions or other solutions that have been effective?
    a. Probes: With additionality? (An offset must produce a greenhouse gas emission reduction that is **over and above business as usual)**
    b. With getting farmers on board?
    c. With perverse incentives?
    d. With government intervention?
9. What ideas do you have for policy mechanisms that could be successful in Minnesota?
    a. What should the roles of each level of government (federal, state, local) be in regulating carbon markets?

MDA role

10. What do you think MDA's role should be in overcoming challenges with carbon markets?
11. Are there other ways you think MDA should be involved with increasing farmer participation in climate-smart practices?

Wrap up

12. Are there any additional things you think we should know or think through?

Thank you very much for your time! We really appreciate it.

We are hoping to wrap up our interviews by the end of March and write our final report in April. We are happy to send you a copy of our report if you are interested. Would you like to be sent a copy of the report?

Yes / No

Great! Have a good day!

Appendix B: Interview Selection and Analysis Methods

To further investigate our research questions, we aimed to conduct 30 interviews with key stakeholders on climate-smart practices and carbon markets. A list of 36 key stakeholders was assembled and prioritized by MDA, which comprised all interview candidates contacted for the first round of interviews. MDA anticipated these stakeholders would have firsthand knowledge and experience with emerging agricultural carbon markets or climate-smart practices. The list included people from government agencies and organizations, farmers and farmer representatives, as well as advocacy and education organizations. Though the list includes a handful of representatives from the private carbon market sector, that pool of interview candidates was deemed of secondary importance by MDA. As the research project progressed, the research team continued to identify candidates for a potential second phase of interviews. However, due to a healthy initial response rate and time restraints, the second phase of interviews was not conducted. In total, 26 interviews were conducted with key informants between March 16th and April 1st, 2022.

Interview candidates were contacted via email, and were provided information about the purpose of the research and potential risks and benefits for participants. Interview candidates were informed that the interviews were voluntary and confidential with the disclaimer that, although their names and titles will not be included in the final report, it may still be possible for MDA to identify them based on the feedback they provide. Interview candidates were asked to sign up for an interview using the website, Slotted.co. After registering for an interview slot, they were contacted again by one of three researchers on the interview team to confirm the appointment.

The interviews were conducted over Zoom, a video conferencing tool. At the beginning of the interview, and before starting audio-visual-recording, researchers answered potential questions related to the consent statement and asked for the individual's verbal consent. If consent to record was received, the researchers then began audio-visual recording.

Interviews were conducted with one researcher present and lasted between 45 minutes to an hour. The original interview guide included 11 main questions that covered the informant's experience with carbon markets and how they interact with farmers' behavior around pre-existing climate-friendly practices. After the first week of interviews, slight changes were made to the interview guide in the form of additional question probes, and a question was added that focused more explicitly on carbon market awareness. The interview also involved a discussion about how pre-existing practices like no-till and strip-till should be valued and how to incentivize them. The researchers were careful about the wording of their questions and the tone used when addressing them to make sure that participants felt comfortable.

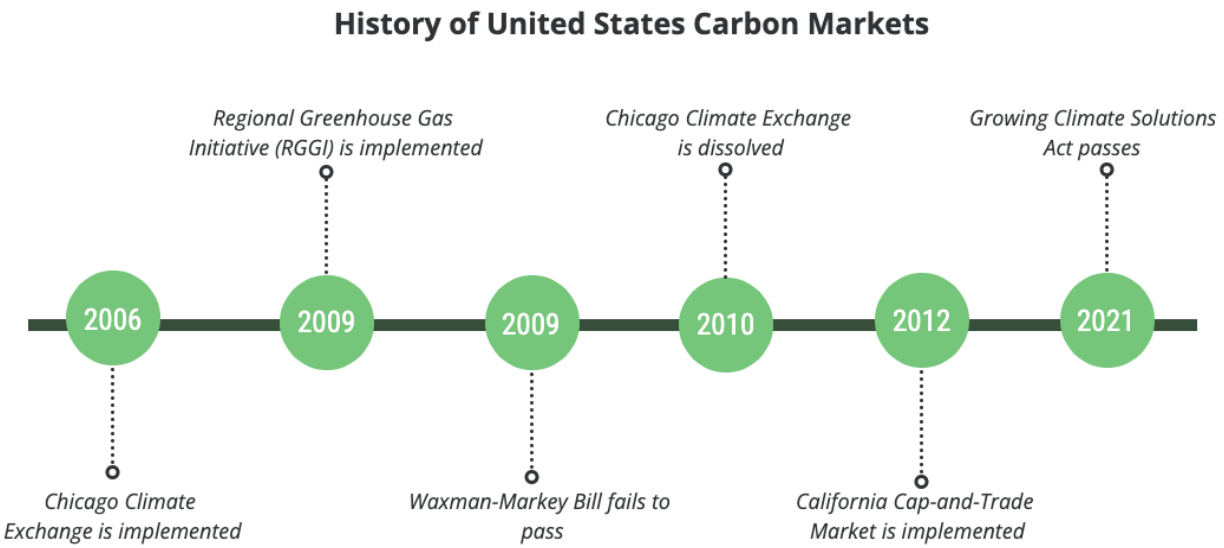
Once all interviews were complete and notes were cleaned, two members of the research team went through the interview notes question by question, to identify relevant themes used to draft the initial codebook. One team member condensed the codebook, pairing like codes and arranging them by category. Interviews were

generally coded by category rather than by question. The three major categories included: barriers for implementing climate-smart practices, carbon market awareness and impact, and types of support and potential solutions. More detailed code categories were nested within these three main categories. A team member uploaded all interview notes and the codebook to Atlas.Ti, a qualitative research software. That team member then coded one set of interview notes at a time. Once coding was completed, the interview team debriefed and another team member wrote up the initial findings and recommendations. Finally, the interview team met again to review the findings and revise recommendations.

There were several limitations in this project regarding the interviews. Largely due to the restraint of time, a more balanced spread of stakeholders was not possible. Ideally, the research team would have ensured a more equitable distribution of stakeholder voices. Notable absenteeism regarding stakeholder voices includes for-profit carbon market constituents, MN Corn Growers Association, and MN Wheat Growers. Though constituents from the latter two organizations were contacted, they did not elect to participate. Additionally, of the 26 total participants, a fair amount were from MFU-FLAG-MAWQCP Climate Guide Project Advisory Committee members. This could be considered a limitation as several interviewees held a seat on that particular committee. Finally, those interviewed were primarily Caucasian and male-presenting which also suggests a limitation in interview findings. Future studies should consider including more diverse perspectives both socially and professionally.

Appendix C: Historic Carbon Market Examples

While carbon markets are still emerging, different models have been tested over the last 15 years. It is helpful to learn from these historic examples and understand the broader federal landscape. The timeline below shows some key points in the US carbon market's development. These include markets that are broader than agriculture but often include an agricultural component. Of particular interest are the Chicago Climate Exchange and California Cap-and-Trade Markets.



Chicago Climate Exchange

The Chicago Climate Exchange was the first national effort to create a carbon market in 2006. In 2008, farmers had over 3 million acres under contract, but by 2010 the market collapsed because Congress was not

able to pass cap-and-trade legislation leaving little incentive to buy carbon offsets. The collapse of the market left farmers who had taken on additional upfront costs with unfulfilled contracts (National Sustainable Agriculture Coalition, 2021).

RGGI

On the East Coast, the Regional Greenhouse Gas Initiative (RGGI) began in 2009 and focused on New England and Mid-Atlantic states. While this program has more participation through industrial industries, farmers can participate as well by reducing methane emissions from livestock, which is the only approved offset activity from the agricultural sector (National Sustainable Agriculture Coalition, 2021). The challenge of this program is that it does not offer ways for agricultural producers to join the program.

California Cap-and-Trade

In 2012, California launched an economy-wide Cap-and-Trade program, which sets a declining cap on carbon emissions that companies can meet by buying and trading carbon credits. Farmers can benefit from this program by methane capture from livestock and reduced methane emissions from rice cultivation. This program works by creating allowances and tradable permits, where one allowance is equal to one metric ton of CO_2 emissions. The idea is that every year, fewer allowances are created and the annual cap declines (California Air Resources Board, n.d.).