Minnesota Soil Health Action Framework

December 2023

The development of the Framework was led by the University of Minnesota Office for Soil Health and the Board of Water and Soil Resources based on discussions with representatives of public and private sector interests in Minnesota's soil health.

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This report is based on discussions of the following group. Including names on this list does not indicate the individuals or organizations approve all the statements in this report. The authors aimed to represent their wide-ranging perspectives, but ultimately the authors are responsible for the content.

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Summary of findings

The purpose of this report is to develop an action framework to increase adoption of soil health management practices. We believe that improving the health of soils across the state means a more stable, financially sound, and productive agricultural sector; healthier lakes, streams and groundwater; better habitat; more carbon storage; and opportunities for flood mitigation through more dispersed water storage.

Soil is managed by farmers and other land managers, but their actions in turn are shaped by a complex web of markets, technology, policy, and social factors. Both the costs and the benefits of soil health are felt by the landowners and managers as well as the public at large. Therefore, improvements in soil health require the engagement of multiple and sometimes conflicting interests. Fortunately, in Minnesota many of these interest groups understand how they can benefit from advancing soil health and have been investing in soil health management for many years.

This document is a framework of desired outcomes, metrics, strategies, and actions, intended to be used by diverse interests to guide their planning for advancing soil health. The specific metrics and actions will not all be relevant to any one interest group. A significant number of the strategies described are already in place and should continue to be supported.

An advisory group representing diverse interests was convened five times in 2022 and 2023. The group (listed on page 2) included representatives of farmer organizations, food and agriculture companies, agricultural co-ops, University Extension, state and federal agencies, local government, agriculture and environment advocacy groups, and other non-governmental organizations. Several of the members were farmers. The group agreed on the value of advancing soil health, shared a broad belief that appropriate actions towards soil health will benefit both agriculture and natural resources, and were energized and committed to discussing and sharing their distinctive perspectives.

Key concepts and priorities

- **Invest in people, not just practices.** Among the common themes that emerged in the group's discussions are the challenges of building expertise in soil health practices and meeting demands for that expertise, across both the public and private sectors. Directing federal and state resources toward expanded training and staffing can help meet these needs at the local level.
- **Expand public-private partnerships across multiple sectors**

What is soil health?

Soil health is defined in state statute as "the continued capacity of soil to function as a vital living system that sustains plants, animals, and humans. Indicators of soil health include water infiltration capacity; organic matter content; water holding capacity; biological capacity to break down plant residue and other substances and to maintain soil aggregation; nutrient sequestration and cycling capacity; carbon sequestration; and soil resistance." (Minn. Stats. 103C.101, subd. 10a).

The U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS) defines soil health more concisely as **the soil's ability to function as a vital, living ecosystem.**

and activities. Public agencies, NGOs, and private companies share many goals for improving soil health across the agricultural sector. In addition to supporting new staff positions, partnerships can expand and enhance collaboration in the areas of research, market and supply chain development, and joint training opportunities to learn from each other and better align messaging.

- **Increase the role of private sector agronomists** by improving their skills and their business opportunities, including developing incentives for agronomists to "sell services" rather than "sell products."
- Support and increase **farmer mentorship and peer-to-peer learning support**, including funding for early adopters to train and mentor others.
- Support soil-friendly agriculture beyond the farm gate by **developing markets and supply chains** for emerging crops as well as formerly widespread crops such as oats, winter rye, and pasture-based livestock production systems.
- Increase funding flexibility by designing **programs to meet farmer needs** (e.g., equipment purchases) and to increase opportunities for **small-scale commitments and experimentation**.
- Develop programs and policies that acknowledge the many **different scales and approaches in agriculture**, as well as the broader issues of access to land, farm transitions and demographic change. These issues can indirectly influence the extent of soil health practices; for example, both renters of farmland and non-operating landowners may feel constrained in their ability to change established practices. Generational and cultural differences can also influence awareness of opportunities and openness to change.

Key differences and disclaimers

Among interest groups, the definition of soil health and purpose of this work varies and is sometimes contradictory. While few of the people in the advisory group support all of the statements in this document, participants agree that the Framework reflects the group's discussions and the greater intent to advance healthy soil.

For example, some members opposed differentiating actions between various sizes or sectors of agriculture, because of concern that it would jeopardize our ability to bridge often-contentious agricultural perspectives in the interest of soil health. Conversely, other members emphasized that different sizes and sectors of agriculture have different needs and different soil health impacts and issues.

To retain all potentially valuable ideas for strategies and actions, we did not limit ourselves to points of consensus or actions of proven impact. A strength of the soil health community is that values and priorities vary by interest group, and thus they will support different strategies. As a group, we cannot objectively identify or rank all the impacts of each action, and the costs and benefits of each action may be assessed and borne by various groups.

Using the framework

This report is deliberately not an "Action Plan" but a framework to guide agencies and private organizations as they develop their own action plans. It is intended to be flexible enough to meet the varied objectives of those agencies and organizations that collaborated in its production, as well as other public and private interests.
Each group can choose from the metrics, strategies and actions presented in this document to advance their own soil health mission and to collaborate with others.

Some ways an organization or coalition might use this framework:

- Share the document with members to facilitate a conversation about their priorities
- Create a survey of clients/members to help them select priorities
- Use the prioritized list of strategies to refine programs
- Choose from among the metrics to set soil health goals and track the organization's progress
- Create policy or advocacy statements backed by the priorities
- Use the priorities to justify grant proposals or funding requests

We will widely promote the Framework as a tool for action planning and collaboration. In the short term, the following organizations are preparing to use the document:

- The Board of Water and Soil Resources (BWSR) will use the framework to evaluate its current soil health programming and authorities, and consider changes in its grant and incentive programs to support public-private collaborative efforts and encourage broader adoption of soil health practices.
- The Minnesota Department of Agriculture (MDA) will use this report to inform its completion of a state healthy soil management plan and pilot grant program, as directed by the Legislature.
- MOSH and University of Minnesota Extension will use this report's recommendations to shape their research and educational priorities.

Context and background

Soil health functions, costs and benefits

Soil health is defined by function: how well it holds, releases and filters water; cycles nutrients; supports plant productivity; and prevents erosion.

The functions performed by soil are summarized by the U.S. Department of Agriculture (USDA) as follows:

- **Guiding the flow of water:** Soil helps control where rain, snowmelt, and irrigation water flow over the land and into/through the soil profile.
- **Sustaining plant and animal life:** The diversity and productivity of living things depend on soil.
- **Filtering and buffering potential pollutants:** The minerals and microbes in soil are responsible for filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposits.
- **Cycling nutrients:** Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled in the soil.
- **Providing physical stability and support:** Soil structure provides a medium for plant roots. Soils also provide support for human structures and protection for archeological treasures.

Among the widely recognized principles for building soil health are those shown in this graphic from the USDA Climate Hubs.[1] Livestock integration is considered part of biodiversity, or it is frequently included as a fifth principle, such as in the principles for soil health described by the Minnesota Office for Soil Health.

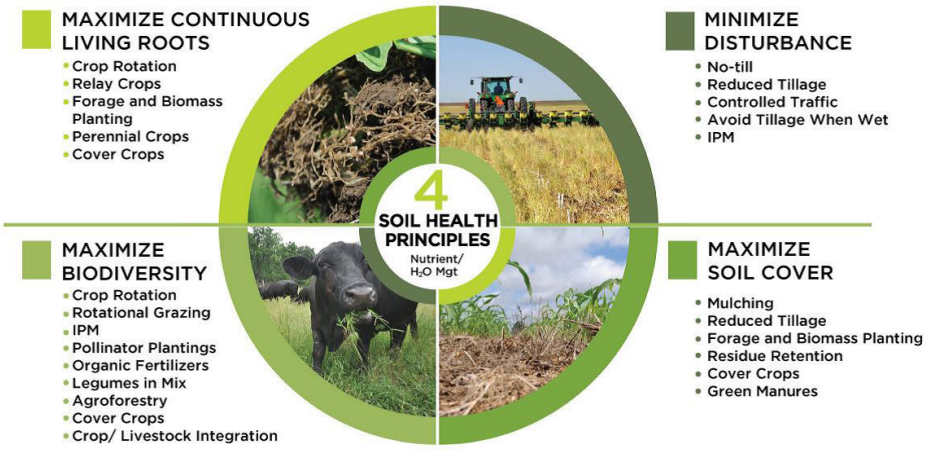


Figure 1. NRCS soil health principles coupled with soil resilience strategies

Soil health can be measured through specific physical, chemical and biological properties, such as soil organic matter, bulk density and water holding capacity, plant available nutrients, and microbial biomass. MOSH identifies some commonly used indicators of soil health.

Information Sources

Several previous reports, studies and state policy plans have informed this process, including:

- **Minnesota Climate Action Framework (2022):** The Framework identifies strategies and actions to improve soil health and reduce GHG emissions in the agricultural sector (see examples in sidebar to right).
- **Minnesota Nutrient Reduction Strategy (2015):** The strategy calls for reducing nutrient levels in major rivers by 10-20% by 2025 from 2014 levels, with much higher reductions by 2040. The five-year review of the strategy (2020) identifies initiatives to "step up" agricultural BMPs, including soil health practices.
- **Working Lands Lead the Way: Policy Priorities for Regenerative Agriculture** (2022): This report by the Midwest Row Crop Collaborative focuses on potential policy solutions for agricultural systems change for consideration in the next farm bill. The report advances a Theory of Change that incorporates common risks and barriers, pathways toward system change, actions and outcomes which has helped to inform this project.
- **Vegetative Cover in Minnesota: Prospects and Challenges** (2020): This report looks at opportunities for pasture and forage, cover crops, small grains and perennial crops to improve water quality in areas with highly vulnerable groundwater. The study includes summaries of interviews with farmers and industry partners with experience or interest in vegetative cover in the Central Sands, Southwest and Southeast regions.
- **Agricultural – Water Quality Solutions Project (2017):** This process, developed by a broad range of stakeholders in the

Minnesota Climate Action Framework: Soil health-related strategies

Initiative 2.3 Healthy Farmland

Accelerate soil health and nitrogen and manure management practices that reduce emissions and enhance carbon storage, water quality and habitat.

- Increase organic carbon content and reduce erosion
- Manage fertilizer and manure to reduce emissions
- Manage land for multiple benefits

Initiative 2.5 Investments in emerging crops, products and local economies

- Invest in climate-smart agriculture and develop markets for climate-benefitting products
- Support local food markets, urban agriculture ad emerging farmers

agricultural sector, resulted in a recommendation to the Governor to "establish and fund farmer-led councils to help implement new practices or enhance current Best Management Practices relating to agricultural water quality." Language authorizing the establishment and funding of farmer-led water management councils by MDA was adopted in 2017.

Two reviews of research literature were completed as part of this project. By summarizing what is known about the implications of each practice, these reviews can help stakeholders and implementers prioritize potential actions.

Scientific literature review: Impacts of Soil Health Management on Environmental Quality: A Research Review for Minnesota. This review summarizes research on the impact of four in-field practices (cover crops, reduced tillage, perennials, and crop rotations) on nutrient losses, soil carbon, and runoff/erosion in Minnesota. The review focuses on data from studies conducted in the upper Midwest.

Social science literature review: This review looks at producer decision-making around conservation practices adoption. It summarizes research findings about how individual behavior is associated with five factors:

- Farm characteristics
- Personal characteristics
- Perceived practice characteristics
- Social factors
- Structural factors

Components of the framework

The Framework is organized around a **theory of change** for soil health. A theory of change is a logic model often used in the social sciences that traces the cause-and-effect steps from current conditions to desired outcomes. For this process, we collectively identified several desired measurable outcomes (i.e., where we hope to end up), and those barriers and current conditions that prevent us from achieving those outcomes, followed by recommended strategies and examples of short-term actions that in turn will create conditions for success.

Desired **outcomes** for soil health in Minnesota include the following:

- Resilient land management
- Healthy natural resources
- A robust agricultural sector and communities
- Efficient and effective public policy
- Widespread commitments to soil health

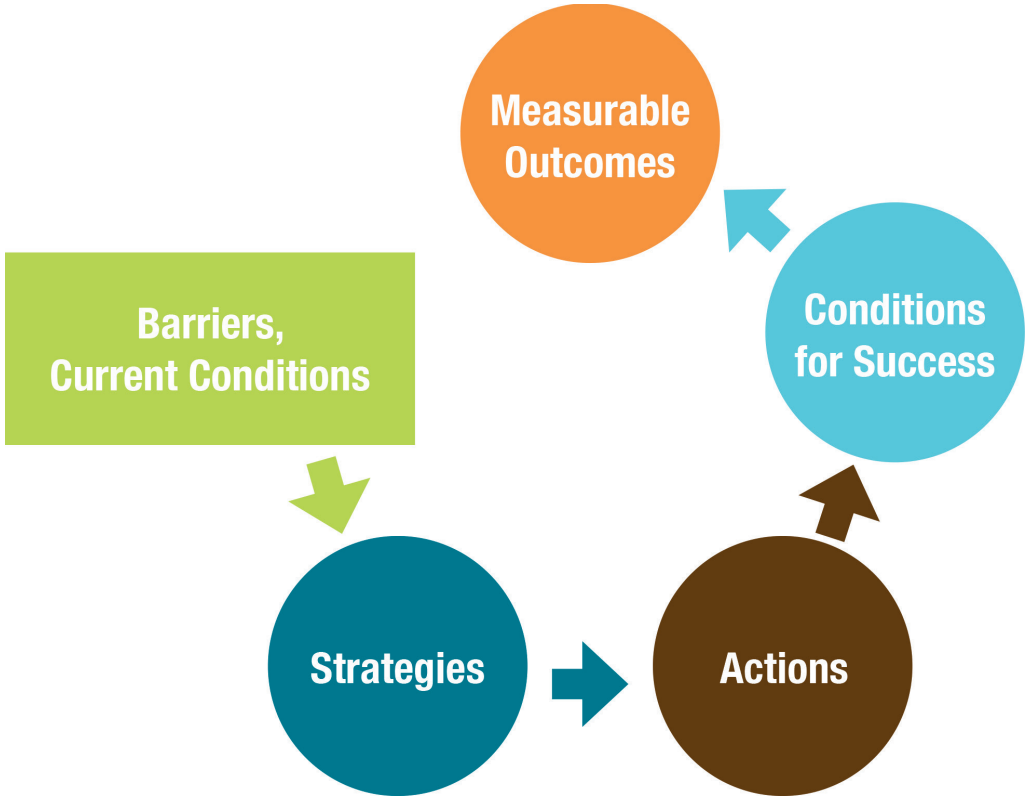


Figure 2. The theory of change summarizes our assumptions about what strategies and actions will produce conditions for success and the desired outcomes.

Goals are milestones and end points. An effective goal is one that is "SMART" – Specific, Measurable, Actionable, Realistic, and Time bound. This Framework does not include overarching goals for soil health, because we believe that goals that are more specific to each participating organization can be more effective and implementable. Goals related to soil health can be found in several existing plans and policies, while additional goals could be developed for other public and private stakeholders. Some examples of soil health goals include:

- Water quality – Goals from the state Nutrient Reduction Strategy
- Water storage – Soil health goals for water storage are seen in WRAPS and One Watershed, One Plan reports
- Climate mitigation – Goals relating to greenhouse gas emissions reduction, such as those in the Paris Climate accord or the Minnesota Climate Action Framework
- Climate adaptation, resilience – Goals for this purpose might measure reductions in soil erosion or increases in ag productivity, profitability, or sustainability
- Community health and agricultural sector health – Goals might focus on disparities in access to land and resources for under-represented or under-resourced populations

Barriers: A starting point for developing this Framework has been to identify the barriers that prevent or delay widespread adoption of soil health practices. Barriers that hinder Minnesota's farmers and ranchers from achieving desired soil health outcomes can be environmental, technological, economic, and/or social. For example, although one of the most effective ways to improve soil health and sequester carbon is to keep farmland covered with vegetation for much of the year, challenges such as Minnesota's short growing season and variable climate; high seed, fertilizer, chemical and equipment costs; and lack of access to trusted expertise all combine to limit cover crop adoption. (Cover crops are currently estimated to be planted on only 2-3% of the state's cropland.) A long historical tradition of tilling the soil also contributes to the lack of year-round vegetative cover.

To address these barriers, we identify four basic conditions for success that would support the widespread adoption of soil health principles and practices across Minnesota:

1. **Agronomic systems of production** that are profitable over the long term and effective at improving soil health
2. **Markets and infrastructure** to make soil-friendly agriculture accessible and profitable
3. **Learning networks and social support** to work out site-specific solutions
4. **Technology (R&D)** to facilitate alternative cropping systems and for monitoring progress

Potential soil health metrics: How do we measure success, or at least progress toward success? Metrics are standards for measuring performance, progress, and change over time, and can be developed based on various parameters, as shown in these examples:

- **Adoption of practices:** Number of farms adopting soil health practices, or acres devoted to a practice
- **Adoption of systems:** Acres or numbers of farms using combinations of practices, participation in certification systems
- **Soil quality metrics:** SOM or SOC, soil structure, soil water-holding capacity
- **Soil function metrics:** water quality, ag productivity, habitat quality, flood mitigation
- **Actions and funding:** levels of state and federal funding, number of program staff, trained advisors, and farmers participating in programs

Additional metrics related to broader social or economic factors could also be developed, such as

- **Access to programs:** The number of historically underrepresented producers with access to programs and;
- **Access to land:** The beginning farmers gaining access to land; or acres available to historically underrepresented individuals or groups.

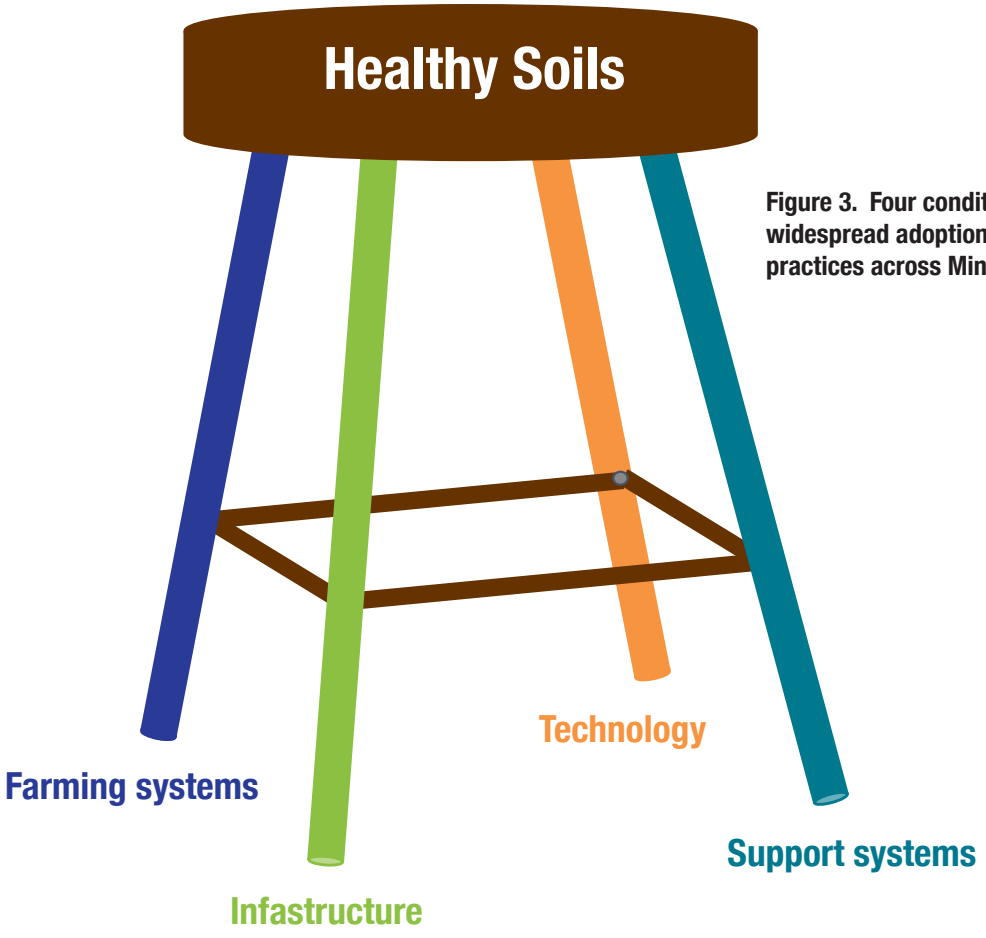


Figure 3. Four conditions are needed to promote widespread adoption of soil health principles and practices across Minnesota.

Strategies for removing barriers

This section examines twelve barriers to advancing soil health, loosely organized in order of priority for action. While there are other barriers, the Advisory Team judged that these priorities need to be addressed first to improve soil health in Minnesota. Each individual and organization faces slightly different barriers and "trip mechanisms," and therefore it's often necessary to address multiple barriers at once.

1. Learning curve and transition time

2. Varied and conflicting perceptions of the costs and benefits of soil health practices

3. Equipment costs

4. On-farm labor

5. Markets and infastructure for emerging crops and integration of livestock

6. Availability of private sector and public sector expertise

7. Land ownership separated from management

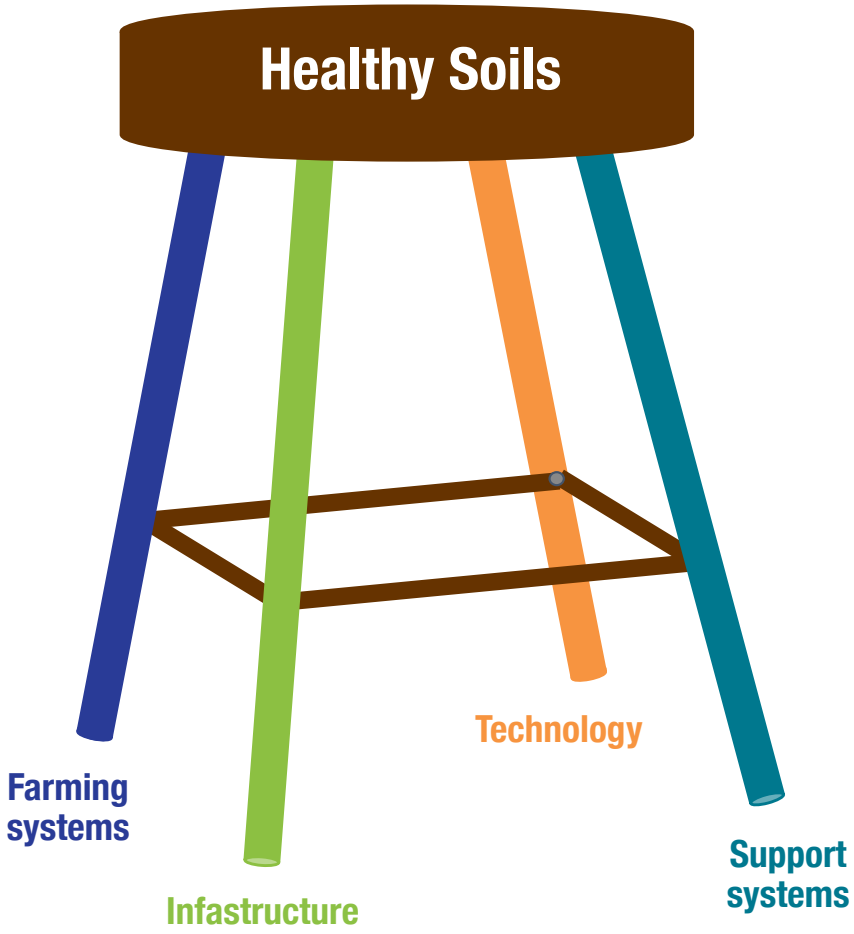
8. Program design

9. Under-developed markets for ecosystem services

10. Inadequate use of social science principles

11. Lack of science-based information about soil health agronomics

12. Lack of data to track progress, impacts, and for decision-support tools



1. Learning curves and transition time

The specifics of soil-friendly farming systems are unique to each operation, complicated to work out, and can take years of learning and practice. Each farmer, operator, or landowner's needs, motivations and interests are different as well. Therefore, solutions must be carefully tailored to the operation and supported by trusted, reliable advisors – no single strategy will work in all cases.
Levels of trust and prevailing social networks also come into play, with differing attitudes among farmers toward public and private sector representatives. Identifying trusted advisors, whether from Extension, SWCDs, farmer cooperatives, agronomists, crop consultants, state agencies, or local mentors, are key to addressing these diverse concerns.

Potential strategies include:

Providing reliable, ongoing technical support, from both public and private sources. This support depends on reliable funding. SWCDs will benefit from more permanent funding enacted by the legislature in 2023. Cooperative agreements between SWCDs, cooperatives, and other private sector providers will also lead to more consistent support for soil health practices and systems.

Peer-to-peer learning support, allowing each farmer to share knowledge and absorb relevant information at their own pace, in a safe, judgment-free setting. A strong support network can mitigate the social risks of "failure," such as late termination of a cover crop.

- This strategy could include curricula and resources for café chats, and support for farmer-mentors and farmer-led learning teams, who often volunteer their time without compensation
- Provide funding for early adopters to train and mentor others

Certification programs provide tailored guidance and give farmers an attainable goal to work towards.

Expansion of the cadre of **agronomists who have soil health and conservation skills** (both the total number of agronomists and their skill levels).

Promote **on-farm research and demonstrations** to bring forward locally-relevant evidence of soil health practices and benefits.

Promote **private-public sector partnerships** to implement public programs and distribute public funding through connections between producers and their agronomists.

From strategies to actions

Peer-to-peer learning support

The Minnesota Soil Health Coalition developed a mentoring program for its members. Several formal and informal soil health teams led by producers have been established around the state.

Certification programs

The Minnesota Agricultural Water Quality Certification Program (MAWQCP) is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that improve water quality. Participants receive recognition, regulatory certainty for a ten-year period, priority for technical and financial assistance, and reliable,ongoing technical support. To date, the program has enrolled more than 1,300 farmers and one million acres.

Private-public partnerships.

Several Conservation Agronomist positions have been created that are jointly funded by agricultural cooperatives and local conservation districts. Advisors in these positions can provide reliable and ongoing support for conservation practices in the same place that farmers are used to receiving agronomic advising and services. Where these positions are in place, demand for their services is high.

2. Perceptions of the costs and benefits of soil health practices vary among farmers and other interest groups

Perceptions are reflected in social norms or expectations about what farming looks like, and social media stories on failures of soil health practices, whether due to weather conditions, equipment failures, or other circumstances. Inconsistent messaging across sectors can increase confusion and sow mistrust.

Potential strategies include:

- Help farmers develop media and presentation skills so they can tell their own stories.
- Maintain communication and collaboration among the interests represented on the Advisory Team for this Soil Health Framework.
- Engage communities in research and demonstrations. E.g. involve community colleges, 4-H, FFA, and others to conduct in-field soil health assessments.
- Expand staffing of Extension and others who are viewed as “unbiased”.
- Develop deliberate explanations of common terms and the purpose of government programs.
- Wherever state agencies and researchers manage farmland, ensure soil health practices are implemented.
- Industry, state agencies, and researchers collaborate on learning and research about whole farm systems, accounting for regional variations.
- Enhance training of the next generation of farmers by promoting soil health education, for example, by forming soil health collaboratives among ag educators (high school & college level).
- Researchers: Focus on ensuring more consistent success with cover crops; prioritize research on perennials and winter-hardy annuals, collecting and analyzing economic data and sharing results.

3. Equipment costs

Equipment costs have been widely identified as a huge barrier to farmers who would like to try out new practices on a small scale or who are ready to convert their whole operation. New equipment for strip tilling, for example, can cost upwards of $300,000, while availability of rental equipment from a co-op or SWCD can be uncertain.

Potential strategies include:

- Provide grant and loan programs to support equipment purchases or rental by producers.
- Support SWCD programs for loaning or renting equipment. Give preference to programs that link technical support to the equipment.
- Support small businesses that provide custom tillage or cover crop services, or rent equipment.
- Provide training for the financial sector (especially smaller banks) to understand how equipment fits in the system, and the advantages of approving financing for such purchases.
- Collect data on the return-on-investment of equipment and services to provide associated services.
- Support retrofitting of existing equipment. Provide more training broadly on what equipment is needed and how to modify equipment.

From strategies to actions

Grant and loan programs

The MDA's Soil Health Financial Assistance grant program, first piloted in 2023, provides grants for the purchase or retrofit of equipment used to establish, improve or accelerate soil health, with up to 50% cost share. The program immediately attracted a huge response, and is being expanded with new state funding.

4. Agricultural labor availability and management

The lack of available and qualified labor was identified as a barrier to expanding or, in some cases, maintaining the same level of operations. Some soil-friendly practices, such as no-till or strip till, can require less time in the field (and less fuel) than conventional tillage practices. In these cases, labor management can motivate adoption of new practices. However, changing farming systems can be a complicated and time-consuming process, requiring shifts in the timing of labor and managing labor bottlenecks.

Potential strategies include:

- Support small businesses that provide soil-friendly custom services such as strip-tilling or cover crop planting.
- Emphasize the time- and labor-saving aspects of soil health practices, in communication with farmers and other agricultural sector participants.
- Continue to develop career pathways in agriculture, from "Minnesota Agriculture in the Classroom" through high school, the state college and university systems, technical training programs and on-the-job training opportunities.
- Incorporate training in practical skills, such as writing conservation plans, in four-year programs.

From strategies to actions

Develop career pathways

The cooperative led Ag Careers Field Day, presented by Centra Sota Cooperative, engages high school students and teacher advisors with state colleges, university systems, and local private agriculture businesses to educate on potential agriculture career pathways.

5. Markets and infrastructure for emerging crops and integration of livestock

Government incentives can facilitate transitions from one agricultural system to another, but ultimately markets and infrastructure that support soil friendly agriculture are needed. Specific needs vary with sector, and different approaches are needed for food systems, energy crops, livestock production, etc. For emerging crops, the infrastructure, markets, and acreage all need to be developed together.

Potential strategies include:

- For emerging crops, build infrastructure for processing, storage, and tracking products from field to consumer.
- Develop markets for emerging crops and products.
- Explore potential to expand small grains to diversify corn-soybean rotations (e.g. oats, winter rye).
- Incentivize local companies to build out infrastructure (e.g., storage)
- Identify risks during market development and help protect small businesses (including farmers) from these risks.
- Develop a joint public-private business model, communications, and research.
- Educate end users about the environmental and health benefits of emerging crops and livestock production systems
- Ensure smaller livestock farmers have support for effective nutrient management.
- Expand the reach of the "Nitrogen Smart: Manure Management" online course offered by Extension.
- Incentivize pasture-based livestock systems through more flexible funding for fencing and watering equipment and for habitat enhancement.

From strategies to actions

Develop markets

The U of M Forever Green Initiative (FGI) program is a coordinated effort to develop new production, infrastructure, and markets in parallel. The FGI portfolio includes over 15 crops, focusing on winter-hardy annual and perennial crops such as Kernza and winter camelina that can keep the soil covered year-round, advancing the key principles of soil health. Multiple funding sources, including federal and foundation grants, have contributed to the program's advancement.

6. Availability of private sector and public sector (agency, SWCD, university) expertise

Similar to shortfalls in the agricultural labor force, a frequently-cited barrier is the lack of both private and public sector staff with expertise in soil health management. Staffing levels at the federal (e.g. NRCS), state, and local (SWCD) levels are often inadequate, and many private sector crop advisors may lack training in soil health management, or be focused on selling products rather than practices.

However, in aiming to increase the number of advisors with expertise in soil health management, we have to pay attention to trade-offs – e.g., what positions are these people being taken from?

Potential strategies include:

- Provide training opportunities where the public and private sector can learn together and from each other.
- Define effective business strategies to help crop advisors minimize risks that may come with this new set of services.
- Direct federal and state resources toward expanding staffing, creating soil health specialist positions at the local and regional level.
- Support creation of joint public-private conservation agronomist positions.
- Continue to develop career pathways in agriculture, from MN Ag in the Classroom through high school, the state college and university systems, technical training programs and on-the-job training opportunities.

7. Separation of land ownership from management

Estimates show about 40% of U.S. farmland is rented, and that percentage may be increasing. According to a Census of Agriculture study, in 2014, 11.6 million acres of Minnesota farmland were rented, out of a total of about 25.5 million acres, or 45%. Land rent contracts can be a barrier to using soil-friendly practices when only the farmer or landowner – but not both -- is interested in committing to the new approaches.

Potential strategies include:

- Targeting more programming to non-operating landowners, specifically women landowners and landowners over 65
- Developing soil health related model rental agreements
- Providing resources and coaching for landowners interested in discussing soil health practices with their renters, and vice versa

From strategies to actions

Programming for non-operating landowners

Climate Land Leaders, the Land Stewardship Project, Women Caring for the Land, the American Farmland Trust and others have developed learning programs and resources targeted to non-operating landowners.

8. Program design (complexity, inflexibility, access)

A common criticism of cost-share and other conservation incentive programs is their complexity and inflexibility. There are stories of farmers walking away from federal and state programs because of the amount of paperwork required, questions about data privacy, or a preference for working independently. At the same time, programs generally don't meet demand. It's estimated that only about 25% of applicants for the primary NRCS programs (EQIP and CSP) receive funding. The challenge is how to increase flexibility while preserving accountability needed for public spending. Some argue that it is not possible to have both flexibility and accountability.

Another challenge of designing soil health incentive programs – public and private – is determining their function. If the goal is to help farmers manage risk, then all adopters (early and late) should be supported. If it is to pay for public benefits, then only those effectively implementing proven practices should be supported. If it is to incentivize learning and transitions, then only new adopters should be supported with short, low-risk commitments.

Potential strategies include:

- Create more joint public-private programs such as conservation agronomists, and involve the private sector in program delivery, including as recipients of program funds.
- Build awareness about the programs available, through a network of trusted "navigators" such as existing program participants and/or MAWQCP-certified producers, who can impartially describe the pros and cons of each program.
- Consider shifting some authority from the state to local governments to ensure more local relevance; similar to water quality improvement funding distributed by watershed partnerships (see right) based on their Comprehensive Watershed Management Plans.
- Consider simplifying or reducing the number of programs. Having a lot of programs with varied rules creates confusion.
- Streamline reporting. Make it easier for farmers to submit reports directly (i.e., without SWCD staff assistance), combine with other reporting, and use remote sensing where feasible.
- Explore methods for tying funding to measurable outcomes, also known as a "pay for performance" approach.
- Design programs for two different groups: those making an initial small commitment to begin exploring change, and those interested in deep engagement and commitment to impactful practices.

From strategies to actions

Watershed-directed funding

Watershed-Based Implementation Funding is increasingly available through BWSR to watershed partnerships that have completed their Comprehensive Watershed Management Plans (under the One Watershed One Plan program). Funding can be apportioned by each partnership to actions identified in those plans, providing a greater degree of flexibility than typical grant programs.

9. Undeveloped markets for ecosystem services

Ecosystem services include the environmental and health benefits of clean air and water, fertile soil, flood control, wildlife and pollinator habitat, and other related benefits (EPA ref.). Markets for ecosystem services need to be integrated with markets for food and feed.

Carbon markets are a type of ecosystem service market that has received the largest share of attention in Minnesota, driven largely by corporations interested in offsetting the GHG emissions of their operations. Several carbon market programs are active in Minnesota, including Ecosystem Services Market Consortium, Truterra, Bayer, and others. However, carbon markets are largely not regulated at the state or federal level, making it particularly important for farmers to understand potential risks and benefits.

One of the biggest challenges to carbon markets is the difficulty of cost-effectively verifying soil carbon storage. Another major challenge is designing markets and programs that support early adopters who continue to protect carbon. Rules for additionality (new practices, new acreage) generally exclude those early adopters, although some companies allow several years of "lookback" credit.

Strategies to improve the operation of carbon markets will likely take time to emerge, as federal policies and standards are developed.

Potential strategies include:

- Promote and advocate for market standards that are comparable across platforms.
- Advise and support producers in meeting standards and avoiding risks (see the example to the right).
- Reward early practice adopters (who may not be eligible to meet additionality requirements) by funding them to train and mentor new ecosystem service market participants.
- Incorporate sliding scale incentives for higher-value practices (e.g., higher payments for multi-species cover crop mixes than for single-species), as some programs do.

From strategies to actions

Advise producers on carbon markets

The Farmers' Guide to Carbon Market Contracts in Minnesota, produced by the Minnesota Farmers Union, MDA, and the Farmers' Legal Action Group, offers plain-language legal guidance on Minnesota contract law as it applies to carbon market contracts.

Identify research and policy needs

The 2022 Ag Carbon Tracking and Monitoring Workshop was a robust process convened by the U of M's Institute on the Environment, culminating in detailed recommendations for researchers, legislators and agency leaders for improving carbon and ecosystem service markets and other climate-smart agricultural practices.

10. Inadequate understanding or use of the social sciences

Applying social science is a barrier that relates to several others. For example, the purpose of improving incentive programs (barrier #8) is to increase adoption of soil health management systems. But is it more effective to incentivize "dabbling" and experimenting, even if there are fewer soil and water benefits, or is it better to incentivize long-term adoption tied to outcomes? Regarding barrier #1 – the learning curve and need for farmer learning networks – what are the actions that would catalyze development of networks? These questions highlight our still incomplete understanding and application of the science of practice adoption.

In addition to adoption theory, two other relevant branches of social science are economics and policy. There are frequent calls for more information about the farm-scale economics of soil health systems, as well as societal-scale economics of soil health costs and benefits. In this project, we avoided delving into specific policy issues, while at the same time acknowledging there are impacts from tax and insurance policies, the federal Farm Bill, land valuation, and more.

Potential strategies include:

- Fund Minnesota-specific research on practice adoption.
- Collect data on knowledge, attitudes, and behaviors to better understand what Minnesota farmers and non-farmers need and want.
- Expand communication and training related to known social science principles.
- Expand collaborations between the University (especially the Center for Farm Financial Management) and the private sector to collect, analyze, and share trusted data on the economic impacts of soil health management systems.

From strategies to actions

Economic impacts of soil health management systems

The Influence of Intensified Environmental Practices on Farm Profitability, a report published by the Minnesota State Agricultural Centers of Excellence (Ag-Centric), has shown that producers enrolled in the Minnesota Agricultural Water Quality Certification Program (MAWQCP) have had higher profits than non-certified farms for four years in a row (2019-2022). MAWQCP-certified producers implement a system of conservation practices that promote soil health and protect water quality and natural resources.

11. Lack of science-based information about agronomics

Farmers need more science-based guidance on how to implement soil health management systems. Research on complex systems is important, but at the same time, meaningful science requires some simplification of systems to understand the impact of individual components like seeding rates, fertilizer practices, etc. Advisors need to correctly interpret and apply research results to make them useful in messy, real-farm situations.

Potential strategies include:

- Involve industry in research and pilot studies to ensure relevance.
- Collaborate with agencies to design research to test assumptions behind programs, such as NRCS Practice Standards.
- Focus research on achieving more consistent success with cover crops.
- Continue public-private collaborations to coordinate development of markets alongside. development of agronomic systems for new crops
- Include research on long-established soil health systems, as well as on the process of transitioning from one cropping system to another.

From strategies to actions

Involve industry in research

From the Discovery Farms program to industry funding of university research, the private sector has long been involved in public-facing demonstrations and research. More collaboration could help identify needs and ensure that relevant equipment and agronomic systems are being studied.

12. Lack of data to track progress and impacts, and to support decision-making

Data collection is desirable to track which practices farmers are adopting, changes in soil health and water quality, and shifting attitudes among farmers and non-farmers. Plus, modeling the effects of land management can inform decisions about what practices to implement and where, and how to design incentive programs. Data collection is essential to determining whether spending on soil health programs is having the desired impacts and to revise activities in a timely way.

On the other hand, data collection has a cost and is often seen as taking away from what could be spent on practice incentives. Also, planning for data collection quickly raises concerns about data ownership and privacy. Decisions about who will collect, analyze, and store the data need to be considered.

Potential strategies include:

- Prioritize research on greenhouse gas and soil organic carbon (SOC) modeling.
- Prioritize research on SOC field measurements.
- Establish a statewide SOC monitoring and modeling network.
- Simplify farm data entry by developing standardized and interconnected systems for program applications (ref. Field Analytics program).
- Preserve data privacy and ownership of data by separating data ownership from analysis/ interpretation tools so farmers can own and control their data and use it with multiple tools.

Additional barriers

Other barriers were discussed that overlap these barriers.

Climate constraints:
Minnesota's short growing season puts significant constraints on windows for field work and the potential for cover crop growth. Variability from year to year means cover crops may be highly successful one year and difficult to establish or a yield drag on the primary crop the next year. Strategies for addressing this include developing business services to facilitate field work, and continuing Minnesota-specific agronomic research.

Low public support and awareness of soil health issues and needs:
Minnesota's comprehensive focus on water quality may have overshadowed public awareness of soil health, although attitudes may be changing as funding and soil-focused programming have increased. Strategies for addressing this include communication campaigns for raising awareness, and engagement with more people (e.g. community colleges, 4-H, and FFA) in monitoring and learning activities. Collaboration across sectors is important to reach diverse audiences with consistent messages.

Science-based information for assessing habitat quality in relation to soil health:
The relationship between soil health and wildlife habitat, including both aquatic and terrestrial habitat, has not been comprehensively addressed. Strategies include collaborations between researchers and habitat/wildlife groups to incorporate soil health components in field research.