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A Message from the Honourable Jeff Leal

Ontario is a land of abundance, with more than 200 diverse foods grown across the province.

We all know that healthy soil is the basis for a strong, sustainable agri-food system. We also acknowledge that there are a number of factors, such as the increasing demand to do more with less, which have resulted in our soils being put at risk.

Our government recognizes that there is a need to enhance our stewardship activities. That’s why we’ve undertaken a number of initiatives such as the Great Lakes Agricultural Stewardship Initiative, the soil mapping initiative, and the Lake Simcoe Soil Health Improvement Program aimed at improving soil health across the province.

In a rapidly changing climate, we must work together to protect our soil while both growing and sustaining Ontario’s capacity to produce food and generate benefits that extend beyond the farm gate, including better water quality and reduced greenhouse gas emissions.

This is why I am pleased to present our draft strategy, which builds on our 2016 discussion document: Sustaining Ontario’s Agricultural Soils: Towards a Shared Vision. This draft strategy proposes ways that our farmers, government, conservation organizations, researchers and others can work together to foster a fundamental shift in the way we take care of our soil. I’d like to thank those who provided feedback on the discussion document, and the members of the Soil Health Working Group (see Appendix 1), for their help in shaping this important draft strategy.

Our farmers have a long-standing tradition of being great stewards of our land, which is why they were integral in helping develop this strategy, along with a diverse group of agricultural, academic and public partners.

By working together with our soil care partners, we have established a strong foundation of stewardship programs, educational materials, research and demonstration sites to promote soil health and encourage adoption of best management practices.

The proposed strategy builds on that strong foundation and proposes new ways to meet modern-day needs. We all know and understand that working harder today to build and maintain soil health over the long term will reap benefits for farmers, the environment and our province.

I look forward to hearing your thoughts and ideas on our proposed strategy. Now more than ever, we must work together to protect our most precious resource.

Sincerely,

Jeff Leal

Minister of Agriculture, Food and Rural Affairs
Minister Responsible for Small Business
Introduction – Healthy Agricultural Soil for a Healthy Future

Healthy soil is essential for life and is the heart of our food system. As those closest to the land and its soil, the farming community understands this.

Healthy agricultural soil has an important role to play in our economy, environment and society. Productive soils are the foundation of Ontario’s agri-food industry—an economic powerhouse that in 2016 accounted for 5.9 per cent of the province’s Gross Domestic Product, employed over 800,000 people and yielded more than $13 billion in farm cash receipts for Ontario farmers. Healthy soil also:

- Helps improve crop growth and increases yields and product quality;
- Improves the rate at which soil absorbs and stores water, and reduces runoff, all of which enhance crop growth and resilience when water is in short supply;
- Helps protect water quality by retaining nutrients (e.g., phosphorus, nitrogen) for crops that might otherwise run off the land into adjacent streams and lakes (supporting the Canada-Ontario Draft Domestic Action Plan aimed at reducing phosphorus in Lake Erie);
- Can reduce greenhouse gas emissions through actions that improve soil health and mitigate climate change;
- Improves resilience to the impacts of climate change such as more extreme temperatures and weather events; and
- Can increase the number of beneficial insects and other soil organisms while reducing pests, thereby contributing to biodiversity and healthier, more resilient ecosystems.

Around the globe, countries and farmers are striving to ensure sustainable, productive agricultural soils for future generations. The United Nations designated 2015 as the International Year of Soils, and the International Union of Soil Sciences has declared 2015-2024 the international decade of soils, to bring global recognition to its fundamental role in sustaining human life through feed, fibre and food security.
Ontario is experiencing a soil health renaissance. There is renewed interest in ensuring policies and programs help farmers address the threats to agricultural soil. This is demonstrated by the ongoing dedication of the partners working together to develop this strategy and increasing government investments in farm stewardship programming. Farmers are taking action to improve soil health on their land.

So what exactly is soil health? Agriculture and Agri-Food Canada (AAFC) defines soil health as its ability to support crop growth without becoming degraded or otherwise harming the environment. The U.S. Natural Resource Conservation Service suggests that soil health is the “continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.”

No matter how it’s defined, soil health is about the interaction of the physical, chemical and biological properties of the soil, and it is vital to long-term, sustainable crop production. Soil organic matter and microorganisms play a key role in all three properties.

Why do we need a soil strategy?

The challenge with soil is that it is often undervalued, or seen as just dirt, and conserving our soils is often overshadowed by issues that are thought to be more pressing.

In its 2015 report, The Status of the World’s Soil Resources, the Food and Agriculture Organization of the United Nations found that the world’s soils are deteriorating due to soil erosion, nutrient depletion, loss of soil organic carbon, declining soil biodiversity and other issues. In addition, over-application of mineral fertilizers and pesticides is having negative effects on soil organisms.

“Our soils are at risk. Our future is eroding. It is time for action.” – Herb Sparrow; from Soil at Risk—Canada’s Eroding Future, 1984

In Ontario, as elsewhere around the world, soil is at risk from many threats1, including:

- Increased demands on soils to grow food and bioproducts for an increasing provincial and global population;
- Changes in cropping, tillage and other practices that can degrade soil health;
- Pressure on farmers to balance short-term economic gain with long-term benefits of investing in soil health and conservation; and
- Increased frequency of extreme weather due to climate change, which can speed up soil degradation.

1 Soil and farmland are also under threat from encroaching development; however, farmland protection is beyond the scope of this strategy and is addressed through Ontario’s land-use policies. Forest, wetland, excess, urban and contaminated soils are also beyond the scope of this initiative because the focus is on agricultural soil. Other public policy addresses these issues such as the Excess Soil Management Policy Framework and associated guidance.
Many of the tillage and cropping practices employed on Ontario farms are considered unsustainable and not capable of maintaining the health and productivity of the soil over generations. Changing this will take determination, cooperation, time and a commitment by many to evolve soil management practices.

While much work has been done to mitigate these threats, there is a need for more strategic and coordinated solutions to ensure everyone involved in soil management is working toward a common vision. The way we care for our soil today will have lasting impacts on our society and farmers. Ultimately, caring for the soil depends on individual farmers taking voluntary action on land they own or rent with the best support from society and partner organizations.

Indigenous knowledge suggests we should consider the impact of our actions on seven generations. Indigenous peoples engage in and have engaged in agriculture in Ontario and across Turtle Island for millennia and Indigenous traditional knowledge and ceremonies reflect respect for the land and reciprocity with nature.
Overview of the Strategy

This proposed strategy builds on the vision, goals, objectives and concepts presented in the Sustaining Ontario’s Agricultural Soils: Towards a Shared Vision discussion document and incorporates feedback from our agricultural and academic communities, as well as technical experts, Indigenous communities, partner organizations and the public. It was also guided by recommendations from the Environmental Commissioner of Ontario².

The final strategy will be a long-term framework, spanning 2018 to 2030, to guide soil health action, research, investments and activities for decades to come. The strategy will be nimble, providing opportunities for adaptive management. We will aim to make the best use of soil science and knowledge as it evolves, including traditional Indigenous knowledge, and monitor our progress to continually improve. These aspects of the strategy are discussed further in the sections Targets for Soil Health and Conservation and Building on Our Momentum: A Future Ontario Soil Health Collaboration.

“We are all responsible. Our challenge is to replace soil degradation with soil restoration. We can counter the fate that history would predict for us. We have the technology and the tools to do that.” Don Lobb, at Soil Summit, August 2017

There is a wide variety of farms types and sizes in Ontario. This strategy is intended to be broad in scope and inclusive of all people who manage agricultural soil on different types of farms. Future research, policies and programs that will serve to implement the strategy will be designed in a way that accounts for the unique circumstances and needs of different types of farmers and their communities.

²The soil strategy is, in part, a major review initiated by OMAFRA in response to a request for review under the Environmental Bill of Rights. The soil strategy also contributes to Biodiversity: It’s in Our Nature, Ontario Government Plan to Conserve Biodiversity.
Building on Success

A community of champions across Ontario have been and continue to be deeply involved in activities that build healthy agricultural soil. From leading-edge research to practical, on-the-ground farm assessments, substantial work is already being done to monitor, measure, restore and protect this valuable resource, including:

- An initiative to improve soil inventory and mapping building on older legacy inventories, investing $5.1 million over two years (2016-2018) in selected areas in southern and northern Ontario;
- Climate Change Action Plan – up to $30 million over the next five years for soil health initiatives (2017-2021);
- Environmental Farm Plan (EFP) – Ontario farmers have completed more than 34,400 EFPs to identify potential risks and develop site-specific actions to reduce concerns;
- Great Lakes Agricultural Stewardship Initiative (GLASI) – targets the Lake Erie basin and southeastern shores of Lake Huron to help farmers improve soil health and improve environmental stewardship with $16.6 million over the past four years;
- The Farmland Health Check-Up – 850 farmers have participated
- Growing Forward 2 – initiatives to reduce greenhouse gas emissions and improve soil health;
- Workshops, field demonstrations and tours hosted by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and other partners;
- Best Management Practices publications, which are collaborative efforts that summarize the state of knowledge and recommended practices;
- Soil Health Interpretive Centre in Elora – cutting-edge research has been initiated at this facility;
- Conferences, workshops and research tours organized by agricultural organizations, conservation authorities and agribusinesses.
- Designation of a Provincial Soil (Guelph Soil Series) during the International Year of Soils.
Ontario’s Draft Soil Health and Conservation Strategy captures and builds on all of this good work, as well as the work of partners, in one cohesive framework. It also draws on the skills and knowledge of farmers, researchers and soil stewardship leaders across the province. The strategy provides farmers, citizens and governments with a roadmap for caring for our soil so that we can continue to enjoy the benefits this vital resource provides. Achieving on-the-ground results depends on the actions of everyone in our sector. And every farmer needs support from their farm organizations, research institutions, technical experts, conservation organizations and government policies to ensure success. From farmers to research institutions, we all have a role to play as stewards of Ontario soils.

Improving soil health is a long-term undertaking. This strategy will guide our efforts and investments to ensure we are meeting our objectives well into the future. It will reinvigorate our collective efforts to have healthy, productive soil for generations to come while, at the same time, supporting long-term profitability for farmers. Ultimately, this strategy will foster a fundamental shift in the way we think about soil, and good soil care will become second nature for more people.
Strategy Development Process

The Agricultural Soil Health and Conservation Strategy is being developed in three stages:

**Discussion Document 2016** → **Draft Soil Strategy 2017** → **Final Soil Strategy 2018**

In 2015 OMAFRA formed the collaborative Agricultural Soil Health and Conservation Working Group—made up of knowledgeable people from farm organizations, agri-food businesses, academia, conservation organizations and the federal government. It was instrumental in developing the 2016 discussion document and has been collaborating regularly to develop this draft strategy. The organizations and their representatives who are members of the Working Group are listed in Appendix 1.

The working group's deep understanding of current and emerging issues, as well as where we are and where we need to go, has been invaluable in this process. The group will continue to support this project as it evolves toward a final strategy. Continued collaboration with our partners will be essential to support its implementation.

Ensuring the health and conservation of Ontario’s agricultural soils is a shared responsibility and will require collective leadership and sustained commitment and action by those directly responsible for managing soil on farms. Key partners include farmers; the agri-business service sector, – which has a critical role in soil management; farm and conservation organizations; educational institutions; Indigenous peoples; government; and, the public.

**Vision:** Healthy agricultural soils contribute to a productive economy, sustainable environment and thriving society

To achieve our vision, we must all work together for the long-term sustainability of the agri-food sector.

As we take another step closer to an agricultural soil health and conservation strategy for Ontario, we invite you to share your perspective. For more information on how to participate, please refer to page 44.
Actions by Theme

The strategy is presented in four overarching themes, which are consistent with the themes in the discussion document but slightly revised for greater clarity. The themes are interconnected and there is some overlap among them, but they have been grouped this way to help focus on the specific issues to develop effective solutions.

All of the elements must work together to bring about the necessary changes, particularly the education, incentives and behavioural change elements to help shift practices over time.

Theme 1: Soil Management

**Goal**
Soil management practices sustain and enhance soil health and productivity for economic, environmental and societal needs.

**Objectives**
- Soil health is sustained and improved to keep farmland fertile, productive and resilient.
- Soil is conserved to support production of, and access to, food and other products.
- Soil is protected from degradation including erosion, compaction, loss of organic matter and breakdown in structure.
- Soil health is enhanced to improve water quality, reduce greenhouse gas emissions and address other environmental issues.
Improving soil health is not a one-size-fits-all endeavour. Ontario is a large province, and the landscape varies widely from the flat, clay plains of southwestern and eastern Ontario to the rolling loamy soils of central and western Ontario; from the shallow soils of parts of eastern and northern Ontario to the sand plains of Norfolk region and the rich organic soils of Holland Marsh. Soils in Ontario, even within a field, are often highly variable. The state of soil health also varies widely, depending on past management practices.

This is why farmers are best placed to make soil management decisions based on their understanding of their fields and crops, their soil test data, the information and tools available, and what works best for their operation. Different kinds of farming involve different practices, so not all of the approaches presented will apply to everyone.

For many years, OMAFRA, researchers and other partners have worked with local farm organizations to establish on-farm research and development studies on a diverse range of soil and cropping conditions to verify the efficacy of soil health best management practices (BMPs). They have found that the following are key principles to improve on-farm soil health:

1. **Diversify crops** – support diversity by planting different kinds of crops over time (crop rotation, in annual cropping systems) and/or plant cover crops to increase soil biodiversity.

2. **Minimize soil disturbance** – manage soils by disturbing them less and by adopting no-till or reduced tillage practices, which helps reduce soil loss through erosion, reduces the risk of structural degradation and allows soil ecosystems to flourish.

3. **Keep plants growing throughout the year** – it is ideal to have living roots and continuous cover from cover crops and perennial crops to help sustain soil life and soil health.

4. **Keep the soil covered** – soil protected by either living plants or plant residue helps retain soil fertility, structure and organic matter, and it also prevents erosion and other degradation.

5. **Build soil organic matter** – application of manure, compost or other organic materials helps maintain and build soil organic matter, soil structure and aggregate stability, and feeds soil ecosystems. Broader and better integration of livestock into crop production can provide sources of manure as a soil organic amendment.

In addition, judicious use of inputs based on nutrient management and integrated pest management approaches can help minimize impacts on soil ecology.

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3 The Food and Agriculture Organization of the United Nations defines Soil Organic Matter as any material produced originally by living plants or animals that is returned to the soil through decomposition. It stores and supplies nutrients, improves soil structure and water infiltration, drives soil biological activity and soil microbial diversity as well as buffers against changes in soil pH. Higher soil organic matter levels improve water-holding capacity, which is critical in seasons with low water.

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**Did you know?** Adding winter wheat in rotation with corn and soybeans increases yield stability, which reduces year-to-year swings in yield—making farm income more dependable.
Another important consideration is soil aggregation—how soil particles clump together—and aggregate stability. Aggregate stability is the ability of soil aggregates to resist breakdown by water or wind erosion, or compaction. Soil organisms are especially important in producing biological compounds that create and maintain aggregate stability.

Best management practices (BMPs) are practical and affordable approaches to conserving a farm's soil and water resources without sacrificing productivity. Soil health BMPs increase organic matter and soil life, improve soil structure, help retain moisture and promote plant growth as well as improve nutrient cycling efficiency. Farmers can choose a particular suite of BMPs depending on what they produce and how they produce it as well as their farm's unique soil characteristics, economics and production challenges.

BMPs should be employed with a holistic, systems approach to realize the synergistic benefits of multiple BMPs and optimize production and environmental benefits (e.g. EFP).

**What We Heard**

Some trends in farming practices over recent decades have had adverse effects on soil health and led to declines in soil organic matter. These changes include:

- more annual crops like corn and soybeans (increased from 28 per cent to 61 per cent of crop and pasture lands between 1976 and 2016)
- more tillage (in 2016 the acreage of no-till declined for the first time since 1991)
- fewer fencerows and windbreaks
- fewer ruminant livestock farms resulting in a reduction in the total area of hay and pasture and availability of manure
- consolidation of smaller fields
- use of larger, heavier equipment

Feedback from our consultations indicated people are noticing these trends.

On the upside, many people who participated in the consultation process told us that they have noticed an increase in farmers planting cover crops. This observation is supported by the Statistics Canada Census of Agriculture which found that farmers doubled their use of cover crops (12 per cent to 25 per cent) between 2011 and 2016.

We also heard about the importance of using a holistic, systems approach to soil management and the need to support the transition to better management practices.

**Action Areas**

Improving soil health hinges on increasing the adoption of soil BMPs. This begins with farmers' knowledge about their soil. A good soil health management plan begins with a farm-level risk assessment and analysis of the appropriate BMPs to address site-specific issues.

Sometimes there are barriers to implementing BMPs. For example:

- High commodity prices make short-term gains more attractive than investments that have longer term payoffs in terms of soil health and yield stability. Short-term farmland rentals and highly leveraged operations are especially vulnerable to these pressures.
- Lower initial yields can result from the adoption of new soil practices.
- What works well on one farm may not work well on another, and there is a management learning curve during adoption, resulting in uncertainty and hesitation to take risks.

OMAFRA and its partners continually improve BMP guidance based on the best available science and knowledge. The latest development is the release of the **BMPs for Soil Health** Factsheet series focusing on best practices for soil health and the **BMPs for Soil Health Diagnostics** Infosheet series aimed at identifying specific problems on farmers’ fields.
Proposed Actions

• Expand the development, enhancement and promotion of the suite of soil BMPs and their adoption.

• Identify and address barriers to the adoption of BMPs, both general barriers and specific barriers for individual BMPs.

More specific actions are needed to move forward on different approaches and tools.

Diversified Crop Rotation

For farms planting new crops each year, having a diversified crop rotation (planting different crops in the same field in successive growing seasons) helps to control pests, more effectively manage nutrients, and improve soil properties and yield, increasing long-term profitability.

However, some crops that might be used to diversify a crop rotation may not have a high value in the marketplace, or markets for these crops are not accessible to Ontario producers. That’s why it is important to continue addressing economic barriers to BMP adoption.

Rather than crop rotation, growers of perennial crop species (e.g. many fruit species) can use other practices to diversify plant species cover.

Proposed Actions

• Government and farm and commodity organizations should explore opportunities to grow markets for crops, such as hay, cereals and perennial biomass crops that support diversified crop rotations. Each organization can incorporate relevant objectives to research, business and market development activities.

Cycle of life with crops and poultry

As one of the first farmers in Ontario to complete an Environmental Farm Plan in the early 1990s, Eric Kaiser has a long history of paying attention to his soil, and he’s passed his enthusiasm on to his son Max.

The Kaisers are located near Napanee in the Bay of Quinte area of eastern Ontario. They have an egg farm and 1,150 acres of crops, including corn, soybeans, wheat, sunflowers, barley and strawberries.

On their farm, the crops feed the animals and the manure feeds the soil. They credit no-till, crop rotation, cover crops and manure as keys to their success. The only time tillage is done is following wheat harvest to lightly incorporate manure and a mixed cover crop is planted to minimize nutrient losses.

Minimizing compaction on their heavy clay soil is also a key goal for the Kaisers. To achieve this, they only spread manure in the summer, use lower tire pressure, and limit traffic to farm lanes and grassed waterways.

Eric Kaiser was named the Ontario Soil Crop Improvement Association (OSCIA) Soil Champion for 2017. He encourages farmers who want to improve their soil to keep it simple and stay committed. He says, “It’s a mindset. You don’t need to try cover crops; you just have to do it.”
Reducing Tillage

Research has shown that excessive tillage has a negative effect on soil health through the loss of soil organic matter, soil biota and soil structure. Yet there are challenges in implementing reduced tillage in many production systems.

Ongoing research and development is needed to continue fine-tuning reduced tillage approaches under different production systems. For example, achieving optimal crop yields in a reduced till system with cover crops in the rotation may require modifications to pest and nutrient management practices and planting equipment. Also, as crop yields increase, new tools and techniques may be needed to effectively manage larger amounts of residue.

Ontario Cover Crops Strategy

Ontario Cover Crops Steering Committee, a group of farmer, commodity and conservation organizations have developed a Cover Crops Strategy for Ontario that will encourage widespread adoption of cover crops on farms in Ontario. The Strategy has four areas of action (research, policy and programs, communications and supporting champions) that will address existing barriers for producers to adopt the practice.

Rotation good for vegetables and soil

Dave Van Segbroek is a big believer in customizing his approach to the crops and conditions on his farm. That's why he uses several different management techniques, including crop rotation on his 1,600-acre farm near Tupperville, in the Chatham-Kent area of Ontario.

He plants winter wheat and red clover in rotation with corn and his main crops which are processing vegetables—including peas, sweet corn, sugar beets, Brussels sprouts and peppers. He figures that if he can break even with the price he gets for the wheat, the rest will be made up in yield benefits in his other crops as a result of healthier soil.

Van Segbroek has won numerous awards for his farming achievements, including a Premier’s Award for Agri-Food Innovation in 2010, in part, because he keeps himself and his workers up to date on the latest production practices through continuous education.
No-till a success for hard-working brothers

At Terwidlen Farms near Bowmanville, the three Barrie brothers decided to go no-till in 1993 when they expanded their cash crop operation by renting 500 acres from retiring farmers in the area.

At the time, it was a new approach and the only way they could see to work all that land profitably. Since then, it’s become an integral part of their success, resulting in lower machinery costs, less fuel use, reduced soil loss through erosion and a better seed bed that’s easier to plant. They now work 1,000 acres, offer custom farming services including no-till planting, and run a robotic milking operation with 55 pure-bred jersey cows.

The Barries continue to stay ahead of the curve when it comes to environmental sustainability. In 2013 they were presented with the Innovative Farmer of the Year Award by the Innovative Farmers Association of Canada.

Keep Soil Covered

To adequately protect the soil from erosion, it’s important to keep it covered with living plants or crop residue as much as possible.

Maintaining crop residue on the soil surface acts much in the same way as mulch does in gardens. It improves soil stability, reduces soil erosion and improves soil health over time.

Cover crops protect the soil by providing cover that helps to slow the flow of water across a field. Farmers are increasingly recognizing the value of using cover crops. Cover crops can be seeded after the main crop is harvested, before later-seeded crops in the spring or in between rows of row crops during the growing season (inter-seeding). In some situations, cover crops can provide feed for livestock. The use of cover crops requires continued research to optimize their use for conditions across Ontario. Crops like winter wheat and perennial crops also provide cover during the critical winter period.

Proposed Actions

• Led by the Grain Farmers of Ontario, the Ontario Cover Crops Steering Committee will implement the Ontario Cover Crops Strategy to encourage widespread adoption of cover crops on farms in Ontario.

• Promote, develop and support use of cover crops through a range of tools including awareness, education, research and incentives.

Applying Organic Amendments

Soil organic matter can be maintained or increased by adding organic amendments such as manure or compost. These amendments are not always available or economical to apply in some locations. Moving compost and other organic amendments to farms that need them has many logistical challenges. Only about 20 per cent of Ontario cropland reportedly received manure in 2016 according to the Census of Agriculture.
Ontario is developing a Food and Organic Waste Framework that will reduce the amount of food that becomes waste and increase the diversion and processing of food and organic waste to create safe and beneficial end-products such as compost and digestate. Compost and digestate can be used as a soil amendment for agricultural and horticultural applications.

**Proposed Actions**

- Promote, develop and support the use of organic amendments.
- Explore opportunities for web-based tools for locating and accessing organic amendment materials.

**Controlling Erosion**

Soil erosion—from water, wind and tillage—is a major form of soil degradation. Left unchecked, it can lead to other forms of soil health problems, such as loss of fertility, degraded soil structure and lower water infiltration rates.

A systems approach should be used to address erosion by water. Planning and risk assessment tools including EFP, RUSLE2 and Farmland Health Check-Up assist with that. The first step is to implement key non-structural, preventative BMPs including crop rotation, no-till or reduced till, residue management and cover crops. Each of these BMPs has its own challenges for different productions systems and crops. No-till is most desirable but is challenging for some high-biomass crops and on certain soil types. Residue management may require specialized equipment and management knowledge. Learning from others can be a crucial way to aid adoption of these practices.

If these non-structural measures are not enough, further protection in the form of erosion control structures may be needed. Water and sediment control basins and grassed waterways, for example, are designed to manage runoff from intense rainstorms. In extreme cases, highly erodible lands on long, steep slopes should be considered for perennial cropping systems or retirement from cropping (e.g. plant trees instead). In some jurisdictions, removing steep, erodible lands from annual crop production is a major focus.

For wind erosion, a workable combination of the following BMPs has been found to be most effective: residue management, cover crops, strip cropping, vegetative wind barriers, field windbreaks and shelterbelts.

Tillage erosion may be more challenging to address. In some cases, more than 70 cm of soil has been removed from the combined effects of ploughing, discing and cultivating. Assessing the extent of erosion will determine which BMPs are most suitable. These could include the addition of organic amendments, cover crops and no-till or longer-term rehabilitation with perennial crops or cropland retirement. If the soil has been deposited in depressions, restoration is recommended. This involves moving soil from depressions to eroded areas and typically requires professional expertise.

Farmers are encouraged to understand their erosion risks and undertake preventative measures. Technical advice and financial incentives are often available.

**Proposed Actions**

- Promote both agronomic and structural erosion control measures and help landowners find the most suitable and effective combination of each for their fields.
- Develop erosion assessment tools that can be used with existing planning tools to provide landowners with ways to determine long-term erosion control benefits or consequences of their management choices (also see Expansion of Soil Erosion Assessment Tools).
Minimizing Compaction

Compacted soil impairs crop production and soil health by reducing the amount of water that can reach plant roots, increasing the risk of surface runoff, reducing root penetration and degrading soil structure. Today there is a greater threat of compaction because farm equipment has become larger and heavier over time. Reducing the axle weight of machinery and using lower tire inflation, or using tracks rather than tires, can reduce the downward force on the soil.

Subsurface compaction may also be in the form of tillage-pans caused by tillage passes (plough, disc, or cultivator) when soils are too wet. Tillage pans can reduce water percolation and root development.

Some farmers use a controlled traffic approach by only driving equipment on permanent wheel tracks in the fields to minimize compaction where the crops grow. Keeping machines out of wet fields also reduces the risk of severe compaction. However, timing of machine use is a challenge for farmers because they are not always able to avoid wet conditions, particularly growers of highly perishable crops like fruit and vegetables. Larger, consolidated fields also increase the difficulty of managing field operations with variable soil moisture conditions.

Proposed Actions

- Raise awareness of the risks of compaction with farmers, agri-business and equipment dealers and manufacturers.
- Help farmers assess their compaction risk, based on their soil type, equipment type and weight, and traffic frequency and patterns to help them identify ways to reduce the risk.

Systems approach means better soil health and stronger profits

At Schuyler Farms, their goal is to be a sustainable farm business, and they are working hard to get there. They see that, in the long term, their soil drives profitability, and their quest to improve soils is also their quest to improve their bottom line. That’s why they have taken a systems approach in their Norfolk County farms where their family grows apples, sour cherries, grains and oilseeds and raise sheep and lambs.

Mapping Schuyler Farms by soil type gives them another tool to understand how to use precision agriculture and how to guide their soil sampling and nutrient applications. It also helps them calculate profits. They feel that if everyone had access to such detailed soil maps, it would really change the way farming is done.

Their farming philosophy is to reduce tillage and inputs without sacrificing yields, use green bin and leaf litter compost, and strive to adopt better farming practices, such as managed grazing, whenever feasible.

Farmers rely on soil for their livelihood so profitability and sustainability go together.
Bringing it all Together

Building and maintaining healthy agricultural soil means taking the time to get to know the soil well and which management practices best suit individual fields. It is important to identify where the risks for soil degradation are and make plans to prevent or mitigate their impact.

Precision agriculture\(^4\) presents an opportunity for site-specific management. By creating management zones based on the field’s inherent soil characteristics (type, texture, drainage and topography), farmers are able to more effectively manage inputs on their fields, work with the limitations of their soil type and address the specific needs of parts of fields, rather than the average needs of whole fields. Good soil management is not inherent in precision agriculture technology, but it can help inform soil management decisions.

Carefully assessing the specific risks and designing a customized mix of BMPs for each farm is one key to success. Tools like the Environmental Farm Plan, Farmland Health Check-Up and Soil Health Check-Up were designed for this kind of activity.

EFPs are voluntary, whole-farm assessments prepared by farmers to increase their environmental awareness and assess risks in up to 23 topic areas. Through local workshops or by accessing the online option, farmers highlight their farm’s environmental strengths, identify areas of environmental concern, and set realistic action plans with timetables to improve conditions, including soil health. The EFP matches particular issues with the right BMPs.

More recently, the Great Lakes Agricultural Stewardship Initiative’s (GLASI) Farmland Health Check-Up and Lake Simcoe’s Soil Health Check-Up programs use the services of Certified Crop Advisors to help farmers assess on-farm soil health and water quality on a few selected fields and develop farm-specific solutions. Some farmers want to go further than the EFP and Farmland Health Check-up. Innovators want to try techniques not mentioned or emphasized in those more general guides. A more detailed tool to plan for soil improvements is also under development for interested farmers.

Proposed Actions

- Examine opportunities to improve soil-related aspects of the Environmental Farm Plan, GLASI Farmland Health Check-Up and Lake Simcoe’s Soil Health Check-Up.
- Examine opportunities to expand the availability of the Farmland Health Check-Up and Soil Health Check-Up tools to other parts of Ontario.
- Develop a detailed soil risk assessment tool to help interested farmers dig deeper to further understand their soils, the risks associated with them, and make plans for improvements.

\(^4\) Precision agriculture is an approach to farm management that uses technology to observe, measure and respond to inter- and intra-field variability in crops for the purpose of increasing input and resource use efficiency.
Making it work with cover crops and no-till

Cover crops and no-till are the perfect pairing for Sara Wood, her husband Chris and mother Deb Little. The team grows corn, identity-preserved soybeans and winter wheat near the town of Mitchell in Perth County.

They take a no-till approach for all crops and always use a cover crop mixture following winter wheat. Cover crops make their no-till system work. Their commitment to this system has paid off by requiring fewer field passes and improved soil fertility.

Sara notes that one of the biggest challenges with their no-till approach is controlling weeds. They also think it’s important to find an agronomist who understands your goals and what you are trying to accomplish. Committing to no-till and cover cropping is a different way of thinking, so Sara recommends reading as much as possible and just taking it year by year.

Invest In and Reward Soil Care

We heard from stakeholders that Ontario needs to invest in building healthier soil. Implementing BMPs can sometimes be costly, often requiring more time to plan and manage. These costs cannot be passed along to the market without affecting competitiveness, as most farmers grow crops for markets where prices are set globally.

It takes time to integrate new practices into a farm management system. Site characteristics like slope, temperature, soil type and rainfall vary from farm to farm, so there’s trial and error involved in getting the right combination of BMPs for optimal productivity and environmental benefit for the soil.

The economic value of the benefits and ecological services of soil health BMPs needs to be quantified. Financial assistance is often needed to encourage the uptake of new practices.

Easily accessible funding and advice to try a different practice on a small portion of land could help some farmers see how it works without significant economic risk. A small grant program could be modelled on similar successful programs in Ontario and elsewhere.

De-Dirting of Carrots in the Holland Marsh

A collaborative research effort between OMAFRA and the Holland Marsh Growers Association, with direct involvement by its member producers and processors, has shown the benefits of upgrading harvesting equipment to minimize soil leaving fields during harvest. Testing showed that de-dirting technology on carrot harvesters can achieve up to 80 per cent of surface dirt removal in the field. Not only does this preserve soil, but it also reduces the amount of water needed to wash the vegetables. This knowledge can be applied to other root vegetables, other geographies and field crops across the province.
Enhanced cost-share funding for a wider range of soil management BMPs has been available in the Lake Erie, southwest Lake Huron and, more recently, Lake Simcoe watersheds and has led to success in changing practices. Broader access to the approach in those programs (the Farmland Health Improvement and Soil Health Improvement programs) would lead to the broader adoption of soil BMPs.

Innovative farmers often lead the way by trying new BMPs or borrowing ideas from other jurisdictions and adapting them to Ontario’s conditions. Innovators often spend their own money to experiment with BMPs, and these experiments often lead to broader acceptance of new BMPs. This innovative spirit needs to be nurtured through policies and programs. A special grant category could be created to encourage innovators to experiment with new BMPs and new approaches to improve soil health.

A variety of programs help farmers manage risk and reduce costs including production-related information and publications, production insurance and property tax incentives. While there could be potential to incorporate eligibility requirements or other incentives to encourage behaviour changes through these programs, Ontario-specific opportunities would need to be explored further.

Growing Forward 2

Four new BMP funding categories were added to the Growing Forward 2 Cost-Share funding assistance program to support producers’ transition to a low-carbon economy. A total of $2.8 million in funding has been allocated for projects under these categories.

Synthesizing the science

Funded through the University of Guelph-OMAFRA partnership, a study is underway to synthesize the current state of science and knowledge to better understand the efficacy of soil-related BMPs at mitigating soil greenhouse gas emissions in different soil types and landscapes.

Soil stewardship is a part of Ontario’s Climate Change Action Plan. The initiative to build soil carbon and reduce net greenhouse gas emissions from soil is a commitment in the plan. Key elements will include research on soil best management practices (BMPs) that mitigate greenhouse gases and on farmer motivations to adopt these BMPs, mapping, modelling and soil management initiatives. This will help demonstrate the value of healthy soil and estimate its contribution to climate change objectives, and contribute to our soil health knowledge.

Greenhouse gas emission offset protocols are being developed under the direction of the Ministry of the Environment and Climate Change for compliance-related offsets for the cap and trade system. Potential for protocol development will be evaluated for nitrous oxide reduction from fertilizer management, emission reductions from livestock, organic waste digestion and management, grassland and conservation cropping. This will lay the groundwork for potential farmer participation in Ontario’s carbon offset market. Ontario-based, quality-branded, voluntary carbon offsets are also being developed to support participation in the carbon market by the Indigenous, northern and agricultural communities and to provide additional environmental co-benefits beyond greenhouse gas emission reductions.
This work will help respond to recommendations from the Environmental Commissioner of Ontario’s report *Putting Soil Health First: A Climate-Smart Idea for Ontario* regarding estimating soil carbon levels and monitoring them over time (also see Soil Evaluation and Monitoring).

**Proposed Actions**

- Expand enhanced cost-share funding (like the Great Lakes Agricultural Stewardship Initiative and Soil Health Improvement Program) for soil BMPs to across the province.
- Support on-farm trials for farmers to start small, try new practices and demonstrate proof-of-concept on their farm (e.g., a small grant funding program).
- Encourage willing farmers to test and adapt innovative methods in soil health through a specific category of grants to allow the innovators to try new practices to benefit soils.
- Examine the potential of other agriculture programs to encourage good soil management practices such as through enhanced eligibility requirements or education.
- Support the development of carbon offset protocols that align with soil health priorities (soil health research findings will help inform the protocol design).
- Develop and implement initiatives that encourage management practices that reduce net greenhouse gas emissions while also benefitting soil health under Ontario’s Climate Change Action Plan.

**Spread the risk and reap the soil health benefits**

In 2015 the three Drudge brothers, who farm at the eastern edge of Huron County near Wroxeter, expanded their crop rotation from corn, soybeans and wheat to include canola, edible beans, oats and yellow peas. The move was in keeping with their successful farming approach—to find adaptive solutions that contribute to the goals of improved soil health and resilient crops. The Drudge Family Farm also includes a grain elevator and a maple syrup operation with 7,600 trees tapped.

With so many crops in rotation, the Drudges have a better buffer against falling prices, take advantage of more planting opportunities in the spring and fall, spread the demands on labour over time and improve soil health over the longer term.

They also say that the variety of crops means meeting more logistical demands in terms of planting, spraying, harvesting and marketing.

The Drudges are long-time no-tillers, and they now seed cover crops following the majority of their main crops, aiming to reach their goal of keeping the soil covered with live plants during as much of the year as possible.

Their advice to others looking to change their soil management practices is to start small and gain experience and confidence with a new way of doing things and then scale up.
Good decisions rely on good data. Technology is becoming increasingly integral to and used in agricultural operations. Information on soils and land is important for farmers to make management decisions. Farmers need better access to data, soil interpretative maps (e.g., susceptibility to compaction), soil maps, and information to support their on-farm decision-making so they can remain competitive in the global market. Policy makers also need access to soil interpretations (e.g., crop suitability), data and information for decision-making, including land-use planning.

For instance, many farmers are using or investigating the merits of using precision agriculture technologies, such as Real Time Kinematic Global Positioning Systems (RTK-GPS), precision planters and yield monitors. The power of this technology has great potential to be harnessed for improved site-specific management decisions with potential soil health and other environmental benefits. However, the key to the successful integration of this technology in crop systems is access to detailed soil maps and landscape information.

What We Heard
There are many partners involved in collecting, generating and using soil data and maps. Collaboration should be the foundation for future actions. We need to make the most of soil data as well as common standards to guide the development and deployment of databases and mapping systems. We also need to build a better understanding of the respective needs and roles of the sector and government.

Data and mapping are considered extremely important for farmers, for monitoring and for understanding what’s going on in the landscape. There were four key points raised during consultations:

- Information privacy is an important consideration in data sharing.
- Soil data should be open and publicly accessible.
- Long-term resources—financial and human—are needed to make progress.
- Some farmers would provide their own soil test data if they were provided with aggregate information to help them make better decisions.
**Action Areas**

**Soil Inventory and Mapping**

Scientists have described, sampled, classified and mapped soils across southern and parts of northern Ontario for over 100 years. However, current soil maps in Ontario are dated, may not be easily used in a digital world and may not be available at an appropriate scale for precision agriculture. Access to up-to-date, easy-to-use soil maps and data layers is critical for land-use planning and precision agriculture as well as to support the work agri-businesses do for their clients.

Renewing soil maps will mean implementing new technologies such as Light Detection and Ranging (LiDAR\(^5\)). This is needed to acquire detailed landscape elevation and topography data and to support predictive digital soil mapping techniques that incorporate computer-based programs, landscape data and field measurement to generate revised soil classifications and maps.

As part of a long-term goal, a two-year pilot initiative (2016-18) to renew soil maps for targeted areas of the province has been initiated with a goal of making Ontario’s soil data and maps more relevant to today’s users.

Ontario and Canada have committed $5.1 million in funding over two years (2016-2018) to support initial soil map renewal efforts in Ottawa, Peterborough, Grand River, Cochrane-Hearst and the Temiskaming Shores regions, with other areas to be considered in the future. Updates to the legacy soil and land capability ratings (Canada Land Inventory) data and maps is ongoing at the same time as the soil mapping.

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\(^5\) LiDAR is a system that measures distance by recording the return time of a laser pulse. In soil mapping, LiDAR is used from an aircraft to accurately record topography.

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**Proposed Actions**

- Continue inventory and mapping to complete provincial coverage of a next generation soil resource inventory and maps over a 20-year cycle.
- Continue updates to the land suitability for agriculture classifications, under the Canada Land Inventory system, to assist in management decisions. In the longer term investigate the development of a next generation land suitability rating and suitability systems that builds on the existing Canada Land Inventory system.
- Complete targeted LiDAR coverage for farmland in Ontario as a foundation for soil mapping, BMP tool development and land resource initiatives.
- Establish a technical/advisory committee to advise on priority areas for soil mapping and LiDAR data acquisition.
Soil Information System

Ontario’s agricultural soil maps are available through OMAFRA’s AgMaps portal on the Agricultural Information Atlas as well as the Canadian Soil Information Service website. As soil data and information is gathered, it requires a secure home for storage, maintenance and public access. A soil information system should be established in a central location and made widely available through a digital platform. It would include existing and new Ontario soil information.

Proposed Actions

- Make existing and next generation soil data available on a publicly accessible, digital platform.
- Identify business requirements and develop a business case for the development of a Soil Information System.
- Determine best practices for standardizing data collection, storage and maintenance and metadata records.

Remote and Proximal Sensing

Remotely sensed data and imagery from satellites and other earth observation platforms are transforming many aspects of contemporary life, and agriculture is no exception. Agriculture and Agri-Food Canada (AAFC) now produces maps and data on the crops that are grown across Canada every year using satellite imagery and advanced computer analytical tools that process the data within the imagery. The availability of these data, in turn, enhances our ability to analyze trends and make decisions.

AAFC is also investigating the use of satellite remote sensing data and technology to map cover crops and agricultural crop residue.

Proximal (direct) soil sensing uses field-based sensors to measure soil characteristics at a high resolution. Information gathered from these sensors, in conjunction with soil sampling and analysis, is becoming increasingly important for defining soil properties in precision agriculture.

Proposed Actions

- Explore ways to use remote sensing data for collection of soil characteristics, information and analysis.
- Explore tools such as airborne or hand-held sensors that can assess soil physical, chemical and biological properties.

Soil Test Data

There is currently a wealth of information in soil samples taken for fertility testing by farmers, consultants, government, academia and others. Farmers and consultants collect soil samples to test for nutrients (such as phosphorus, nitrogen and potassium), organic matter and other soil parameters that are important for crop production. Tens of thousands of soil samples have been collected, with the data housed with many institutions in filing cabinets across the province.

In its present form, these data cannot be easily accessed and used to look at trends or track the state of our soils. Ideally, there should be greater access to at least some of the wealth of soil test data that has been collected in one or a series of databases. This could be used to establish baseline levels of various soil characteristics, assess provincial, local and field-scale trends, and map soil test characteristics at different scales.

However, there are many issues to consider in making soil test data more accessible.

- Privacy: Individual soil tests by private landowners are generally the property of those landowners and may be subject to legal protections. Other tests done for public agencies would not be constrained in the same way.
• Data management: A suitable location for data storage and management would need to be determined. For instance, a consortium of private laboratories could pool soil test sample data for many clients to address concerns related to government access. A university or consortium of academic institutions might be another approach worth pursuing.

• Use of data: Consideration would need to be given to use of data provided by farmers or others—for what purposes and in what form would be the most useful.

• Data standards: There needs to be a standard method for data collection, analyses and outputs, to enable consolidation of data for use in analysis.

Stakeholders, along with experts in data ownership, use and privacy, would need to work through these issues together.

**Proposed Actions**

Engage stakeholders in discussion on how to move toward greater accessibility of soil test data.

• Explore how to address privacy issues and roles of labs and clients.

• Explore data sharing partnerships among multiple partners.

• Examine collaborative arrangements for data sharing among federal, provincial and territorial governments, and stakeholders.

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**Precision Agriculture Data**

Similar to soil test data, there is a growing amount of soil and crop information generated by producers involved in crop-related precision agriculture. Site-specific farming methods combine GPS and supportive technology along with modern farm machinery to collect very detailed information on crops harvested, yield, elevation and topography, and precise geographic location. But good soil management is not inherent in precision agriculture technology, it simply provides new and powerful data tools to make soil management decisions.

Precision agriculture is a rapidly changing, market-driven area in both technology and data analysis. There are currently multiple industry players and platforms, creating challenges with compatibility for software and data. Ontario Agri-Food Technologies has several on-going programs to invest in innovative agricultural products and services, research needs, collaborative projects among member organizations. In addition, these programs may facilitate investments in enhancing the compatibility and availability of data for use in precision agriculture.

**Proposed Actions**

• Work with Ontario Agri-Food Technologies and others to explore data use and sharing from precision agriculture.
Farm Practice Data

There is currently no good source of information about what practices are used by farmers that may affect soil health and conservation in Ontario. Establishing baselines is essential so that improvements in soil health can be monitored over time and so we can understand emerging trends. Baselines on tillage, cover crops, organic amendments, crop rotation and other practices are crucial to measuring progress.

However, a wealth of data exists that could be analyzed. This includes the Census of Agriculture, the Farm Environmental Management Survey, remote sensing data (e.g. AAFC annual crop inventory), collections of soil test data, academic research, and BMP adoption data from federal-provincial and conservation authority programs.

Proposed Actions

Complete an initial project to assess the state of soil-related agricultural practices and establish baselines from which to measure change.

- Compile existing information such as census, Farm Environmental Management Survey, existing remote sensing data (e.g. AAFC annual crop inventory), aggregate soil test data and BMP adoption data
- Establish a partnership with Statistics Canada for in-depth analysis of data on select practices
- Identify data gaps and baselines to measure change in practices over time.

Theme 3: Soil Evaluation and Monitoring

Goal
The health and status of Ontario’s agricultural soils are tracked over time.

Objectives
- Capacity is developed to track changes in agricultural soil health, erosion and soil organic matter.
- Soil health and erosion monitoring is used to inform and evaluate policies and programs.

We can only manage what we understand. We need to assess the state of agricultural soil health over the varying landscapes of Ontario and track changes over time. To do that, we need the right metrics and tools to apply at different scales: at the farm, over different regions and across the province. We also need to understand the linkages between these scales.

The best way for farmers to monitor the health of their soils is to regularly explore it—whether it’s using a shovel to see what the way it looks and feels like beneath the surface, or sending a soil sample to the lab for analysis.

Tools that measure across the landscape provide a regional or watershed picture of what’s happening. Some conservation authorities and local governments work with farmers to monitor their soils and help them use BMPs to improve soil conditions.

Province-wide soil measurement tools are not well developed. Creating Ontario-specific soil
health indicators and making them consistent and comparable at different scales would increase their usefulness.

It is also important at the farm, regional and provincial scales to identify change signals and adapt our management approaches and policies accordingly, and in a way that is transparent and builds public trust in Ontario agriculture.

What We Heard

There is a need for simple ways for farmers to measure and track soil health on their farms. Some tools used by farmers include fertilizer and organic matter tests, earthworm counts (which are an indicator of biological activity) and tests used to demonstrate the rate of decomposition by soil organisms.

Having easy-to-use measurement tools on-hand to do quick assessments would greatly benefit farmers when they are making production and management decisions.

There is also a need to track progress at regional and provincial scales so we can monitor the effectiveness of our collective actions and inform future policy and program decisions.

Proposed Actions

- Create and distribute a farm-level, all-in-one education tool kit for soil health assessment that extension staff and farmers can use. This could include slake tests, infiltration tests and soil compaction measurement.

Understanding the physical, chemical and biological conditions of the soil can be achieved a number of ways.

On-farm soil health assessment, digging through the soil, seeing soil profiles throughout the fields and testing soils to measure and track the nutrients as well as organic matter all help the farmer understand soil conditions.

With rapid advances in technology, there are a number of tools available and many opportunities for more that put soil health monitoring and evaluation at farmers’ fingertips. Mobile applications for smartphones are emerging to assist farmers with their management decisions, and there is great potential for further innovation. For example, open source satellite imagery could be used to track soil cover.

Action Areas

Farm Scale

Improving soil health is a long-term commitment, and it can take decades (or more) to see a measurable change. A significant and sustained commitment at the farm level is critical. This starts with testing soil regularly, understanding the results, planning for change, and taking action. All farmers should be testing their soils.
Organic Matter as a Key Indicator

Soil organic matter stores and supplies nutrients; improves soil structure, aggregate stability and water infiltration; drives soil biological activity and soil microbial diversity; and, buffers against changes in soil pH. Higher soil organic matter levels improve water-holding capacity, which is critical in seasons with low water.

Tracking soil organic matter levels across farmers’ fields is an important indicator of soil health, and it’s easy to include in soil sample analysis. However, benchmarking and tracking soil organic matter beyond the farm scale is a challenge, because different laboratories use different analytical methods. There may be an opportunity to improve consistency in the approach to analyzing soil organic matter.

**Proposed Actions**

- Work with the Ontario Soil Management Research Services Committee and laboratories to explore opportunities for a more consistent approach to soil organic matter analysis across the province.
- Promote the importance of tracking changes in soil organic matter as a way to monitor soil health.

Soil Health Testing

Different laboratory tests can be performed to measure soil parameters. Traditional soil testing determines the pH, estimates available nutrients to predict a crop response to added fertilizer and, if requested, soil organic matter. On the other hand, soil health tests provide a measure of soil health and include indicators for biological, physical and chemical components. This is useful for tracking soil health over time.

Some laboratories offer various soil health test packages. OMAFRA staff and researchers in Ontario are working on validating soil health tests such as the Cornell and Haney tests for Ontario conditions. The next stage is to work with laboratories and other stakeholders to make a validated soil health test available at labs serving Ontario farmers.

Refining these tools and making them easy to use at the farm level is one way to ensure accurate information to better inform farmers’ soil management decisions.

**Proposed Actions**

- Develop and implement an Ontario soil health test in collaboration with laboratories over the next five years.

Expansion of Soil Erosion Assessment Tools

Tools are available to help farmers assess how much soil erosion is happening on their fields (such as RUSLE2®). However, these soil erosion assessment tools need to be packaged into software that is already commonly used by the industry. That way, land managers can accurately assess the soil degradation consequences of their decisions while reviewing their production activities.

Developing and maintaining significant behind-the-scenes datasets is also needed, as discussed in the previous theme area. Examples include detailed, up-to-date soil maps that characterize the soil on a field, regional and possibly real-time rainfall and snowmelt intensity information, and a layer that describes the topography of a field.

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6 Revised Universal Soil Loss Equation is a mathematical model that estimates average long-term soil loss from sheet and rill erosion caused by rain and related overland runoff along a field hillslope.
Ideally, an approach that combines soil health assessments as well as erosion models and tools would be available to farmers, extension personnel and industry agrologists to help them assess, reduce and prevent erosion.

**Proposed Actions**

Expand OMAFRA’s and partners’ capacity in soil erosion assessment:

- Enable development of tools to estimate soil erosion under different management practices (e.g. like “Soil Calculator” or equivalent).
- Continuously improve/maintain these erosion assessment tools as new approaches become available. For example, integrate and verify the recently developed gully erosion estimator with RUSLE2 to provide land managers with better estimates of sheet, rill and gully erosion rates and to assess the effects of different practices on controlling these rates.

**Regional Scale**

Understanding soil health on a landscape or watershed scale develops understanding of the state of soil health on a regional level. For example, watershed-scale soil assessments are conducted by some conservation authorities, which sample and analyse soil at different scales to determine the effect of soil health on water quality and quantity. In-field monitoring is combined with Geographic Information Systems (GIS) techniques to better relate the field to watershed scales. Both scales are important in assessing overall watershed health.

These assessments can take various forms including direct field measurement and risk analyses studies. Direct field measurements can be challenging due to weather and labour requirements, whereas risk analyses studies can rely on land management data that is not readily available. There is a need to strengthen the understanding of the link between direct field measurements and the GIS-based watershed scale assessments.

A regional soil assessment can be a powerful tool to evaluate baselines, measure progress and raise public awareness in the community about the health of local soil. Expanding these assessments to other watersheds would help identify areas in need of action for improved soil and watershed health. Many conservation authorities and municipalities routinely undertake watershed or sub-watershed studies that examine water quality, quantity and habitat issues. Inclusion of soil health analyses in more of these studies would also help increase attention on the need for soil health action.

**Proposed Actions**

- Explore the potential to ensure continuation of existing monitoring and expand watershed soil health assessments to other watersheds.
- Incorporate consideration of soil health and conservation in water quality assessments (e.g., sub-watershed plans) where possible.

**Soil health is linked directly to water quality**

Healthy soils with good infiltration and aggregate stability reduce surface runoff and topsoil loss, resulting in better water quality. The Ausable Bayfield Conservation Authority (ABCA) is currently completing a project to gain a general understanding of the state of soil health across the entire 2,400-square-kilometre ABCA watershed. Various approaches have been used at different scales including side-by-side trials at the field scale, sub-watershed risk based assessments and watershed-wide soil health sampling. A clearer understanding of the link between scales is needed to better assess soil health across the entire watershed. Future work includes developing improved techniques to relate direct field measurements to the watershed-scale assessments.
**Provincial Scale**

Measuring, estimating and tracking soil health indicators is a complex undertaking. Agriculture and Agri-Food Canada leads this analysis, resulting in Canada’s *Agri-environmental Indicators* which are reported on every five years.

The three key soil health indicators used by the federal government are soil organic carbon, erosion risk, and soil cover (including crops, residue and snow). They are considered the best available measures of the status of Ontario’s soils. They can serve as the initial measures of progress for the soil strategy. There is a unique opportunity to adapt them to a more detailed scale that would provide more Ontario-specific information.

Other sources of data that can help track soil health at a provincial scale include the global soil organic carbon map being developed by the Food and Agriculture Organization of the United Nations, and Ontario’s Land Use Carbon inventory\(^7\), which is also under development.

In order to have a robust monitoring and evaluation system, Ontario needs to have an organized system of collecting, retrieving and analyzing data and maps.

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**Proposed Actions**

- Adapt the AAFC soil indicators to a more refined scale.
- Explore options to calculate indicators at more detailed scale (e.g., apply algorithms to more detailed soil maps)
- Assess data on management practices at detailed scale (using census data)
- Explore greater federal-provincial collaboration on indicators
- Examine adaptation of a specific set of indicators for Ontario including soil organic carbon, erosion risk and soil cover
- Examine options to track and report on changes in soil carbon.
- Options include continued participation in the development of a Global Soil Organic Carbon Map, Ontario’s Land Use Carbon Inventory development, AAFC’s soil organic carbon indicator and analysis of soil test data from labs

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\(^7\) Ontario’s Land Use Carbon Inventory project is an Ontario Climate Change Action Plan initiative. The project’s purpose is to develop a land-use carbon inventory for Ontario by 2020 to quantify greenhouse gas emissions and removals from agriculture, forestry and other land uses.
**Targets for Soil Health and Conservation**

Making our goals and objectives come to life means having measures to assess progress over time, and use those measures to set targets for improvement. Yet any targets selected must be meaningful and flexible as well as reflective of the individual needs of farmers and their soils.

At a farm or field scale, OMAFRA suggests that farmers adopt targets suitable to the soil type and circumstances for their farms. These suggestions are based, in part, on recommendations from other OMAFRA publications, as well as expert input. They may be refined over time as our soil knowledge evolves:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Farm-scale Target</th>
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<tbody>
<tr>
<td>Soil Organic Matter</td>
<td>Target at least a ‘good’ rating based on soil texture:</td>
</tr>
<tr>
<td></td>
<td>Sandy Soils: 2.5 per cent, Sandy Loams: 3.5 per cent, Loam Soils: 4 per cent</td>
</tr>
<tr>
<td></td>
<td>Clay Loams: 4.5 per cent, Clay Soils: 4.5 per cent</td>
</tr>
<tr>
<td></td>
<td>(see Ontario’s Agronomy Guide for Field Crops - Publication 811 for more information)</td>
</tr>
<tr>
<td>Crop rotation</td>
<td>At least three crop families in a rotation (for annual cropping systems)</td>
</tr>
<tr>
<td>Cover crops</td>
<td>50 per cent of a farm’s annual cropland have a cover crop</td>
</tr>
</tbody>
</table>

In addition, other targets could be developed related to tillage, organic amendments and other measures, as our data and experience evolve.

The Soil Strategy proposes many actions to support Ontario farmers meeting or exceeding these targets. These include supporting education, site-specific planning, and accessing resources and tools. Collectively, these actions will drive action at the farm level.
Monitoring permanent study plots with established management regimes is another common and complementary method of soil monitoring that provides more detailed, precise measures of change, compared to modelling. Ontario has permanent plots established at a number of research stations (AAFC and University of Guelph) across the province.

The renewed soil mapping and inventory work presents another method of evaluating change in soils over time. Soil surveyors are now able to compare soil profiles from original soil surveys, done early in the 20th century, with current profiles. This can reveal changes in different soil horizons or layers, something not revealed by other methods.

As technologies advance (e.g., remote sensing) and new information becomes available, it will continue to enhance our understanding and ability to monitor change.

**Proposed Actions**

- Adopt the following long-term provincially desired outcome targets:
  - Increase soil organic carbon—reverse the decline in soil organic carbon and stabilize or increase soil organic carbon over time
  - Reduce soil erosion risk—lower risk of erosion and area of cropland in higher risk categories over the long term
  - Increase soil cover by increasing use of cover crops, perennial crops and leaving residue on the surface
- Use the existing AAFC soil indicators and any subsequent adapted indicators to track improvements in soil organic matter, erosion risk and soil cover.
- Promote farm-scale soil organic matter targets for soils of different texture:
  - Sandy Soils: 2.5 per cent, Sandy Loams: 3.5 per cent, Loam Soils: 4 per cent, Clay Loams: 4.5 per cent, Clay Soils: 4.5 per cent
- Promote the following practice-based targets as suggestions for farmers:
  - Crop rotation: At least three crops in a rotation (for annual cropping systems)
  - Cover crops: 50 per cent of a farm’s annual cropland have a cover crop
  - Evaluate changes in benchmarked soil profiles across the province on an ongoing basis to monitor changes to the landscape and effects of cultivation on soil profiles (through the soil inventory and mapping).
- Examine the potential for ongoing monitoring of permanent soil plots across Ontario. This could include examining the potential for expanding the number of permanent plots to adequately cover the range of soil, climate and cropping systems for Ontario.
Theme 4: Soil Knowledge and Innovation

Goal
Soil knowledge and skills are optimized to meet societal and economic needs and drive innovation.

Objectives

- Sustain human resource capacity in soils knowledge to meet priorities.
- The education sector supports programs for appropriate soils knowledge and skills.
- Ongoing research supports innovation in soil knowledge and management.
- Agricultural sector engages and has access to people with soil-related knowledge and skills to meet client needs effectively and economically.
- Producers have access to the knowledge and support needed to maintain and enhance soil health.

Getting the best available knowledge in the hands of decision makers can lead to the best decisions. Knowing how to manage soils and understanding how soils function is key to their productivity and long-term sustainability. However, there is still much to learn about the connections between healthy soils, productivity and resilience.

Investments in education and capacity building are foundational to building awareness and driving behaviour change. This will require sustained, collective leadership. It will rely on commitment and a coordinated effort from farmers, commodity groups, general farm organizations, conservation organizations, agri-food businesses, government and other partners. We need to work together to ensure that lessons from research and the field are shared and incorporated into the development of effective programs and policies. We also need to ensure that knowledge about building healthy soils gets into the hands of people who can best use it: farmers and the people they work with.

OMAFRA and many partners, including innovative farmers, agri-business, researchers and conservation agency staff, provide workshops and informal, hands-on training to consulting agronomists and farmers. They help them learn how to diagnose the key forms of soil degradation, and assess the site-specific efficacy of soil health BMPs on Ontario’s croplands.

Ultimately, we are laying the groundwork for what is needed to better manage our soil, as described in the first theme.

What We Heard

There is limited site-specific (e.g., by production type) research and information, as it relates to Ontario conditions, readily available for those who need it. Ensuring timely, up-to-date information on the latest BMPs, maps and evaluations is available and accessible to farmers is important. We also need knowledgeable government, academic and industry support to assist the sector with these efforts.

Modernizing the ways we communicate is essential for keeping pace with the changing times. We need to diversify the formats of our educational and communication products to
better reflect the range of media and distribution channels used by today’s farmers and other interested audiences.

Indigenous participants spoke of the importance of learning from local knowledge keepers, who have traditional knowledge and a relationship with the land and soil.

Local knowledge was a common theme throughout input received. We also heard that farmers learn the best from each other. In addition to informal conversations, common approaches include practical workshops, demonstration sites and ‘twilight tours’ – in which a farmer will host a group of farming neighbours to learn about his or her practices. Farmers want to be able to see how someone else in their area have implemented soil health practices and what the results were.

We also heard that it’s important for people to know where their food comes from, to get young people excited about soils at an early age, and ensure they develop an appreciation about the importance of soil, seeing it as more than just ‘dirt’. It’s important to attract and train the next generation of soil management professionals so they have the skills and knowledge required to support ongoing stewardship efforts and continuous improvement.

Action Areas

Research

There is still much to learn about agricultural soil and the best ways to manage it in modern agricultural production. Significant improvements in soil's physical, chemical and biological characteristics happen slowly, sometimes over decades. A longer-term, multi-disciplinary approach to researching management systems is needed. Further to that, research needs to be linked with practical, on-farm knowledge and used to develop decision tools to help farmers use this knowledge.

As we do this, it is important to include economic implications. Many social, logistical, behavioural and convenience factors influence choices as well. These factors have often been overlooked, but they are increasingly being considered in addressing barriers to adoption.

In April 2017, a soil research workshop was held with researchers, experts, conservation authority staff and industry representatives to discuss and prioritize areas of soil research. The priorities identified by the group were further refined by OMAFRA staff and an array of academic researchers, experts and industry representatives.

The more detailed proposed soil research priorities are included in Appendix 3. Here are some highlights:
## Proposed Research Priorities for Soil Health

<table>
<thead>
<tr>
<th>FOCUS AREAS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems Approach</td>
<td>- Encourage a multidisciplinary approach to soil health research, which considers the production system.</td>
</tr>
<tr>
<td>Physical</td>
<td>- Quantify the impact of land management on soil physical and hydraulic properties and their influence on soil health (including resilience):</td>
</tr>
<tr>
<td></td>
<td>• Diverse crop rotation with and without perennial crops, cover crops</td>
</tr>
<tr>
<td></td>
<td>• Effects of tillage (no till, rotational tillage, strip tillage)</td>
</tr>
<tr>
<td></td>
<td>• Effect of crop residue removal, in interaction with other practices (what is tolerable removal levels)</td>
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<tr>
<td></td>
<td>• Specific cover crop species (including precision management)</td>
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<tr>
<td></td>
<td>• Soil compaction</td>
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<tr>
<td></td>
<td>• Determine key indicators for soil physical properties.</td>
</tr>
<tr>
<td>Chemical</td>
<td>- Assess impact of soil health practices on the fate (crop uptake, soil retention, loss from system) of nutrients in cropping systems regardless of source (soil, fertilizer, organic amendments, crop residue, etc.)</td>
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<tr>
<td></td>
<td>- Assess chemical changes as soils become healthier</td>
</tr>
<tr>
<td></td>
<td>• Priority nutrients (N, P, K, S, and organic C)</td>
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<tr>
<td></td>
<td>- Consider unintended consequences and trade-offs when conducting systems analysis</td>
</tr>
<tr>
<td></td>
<td>• Build on long term research</td>
</tr>
<tr>
<td>Biological</td>
<td>- Identify and link key functions for a healthy soil with on-farm management</td>
</tr>
<tr>
<td></td>
<td>• Identify indicators that can be used for short term and long term sensitivity to management changes</td>
</tr>
<tr>
<td></td>
<td>• Determine the links between management practices (e.g. crop rotation, cover crops, organic amendments), production and soil biology</td>
</tr>
<tr>
<td>Economics</td>
<td>- Develop methods to quantify economic aspects of soil health</td>
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<tr>
<td></td>
<td>- Evaluate the economic impact of physical soil degradation</td>
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<tr>
<td></td>
<td>- Conduct a cost/benefit analysis of BMPs as related to crop productivity/profitability/sustainability</td>
</tr>
<tr>
<td></td>
<td>- Integrate economic considerations as a deliverable for project funding where applicable.</td>
</tr>
<tr>
<td>Social Factors</td>
<td>- Identify key behaviour barriers and drivers, and the most effective approaches to address them.</td>
</tr>
<tr>
<td>Indicators</td>
<td>- Identify key indicators or functions for the chemical, physical and biological aspects of soil health at the local, regional and provincial scale</td>
</tr>
<tr>
<td></td>
<td>- Develop a clear list of robust measureable soil health parameters</td>
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</table>
Since many BMPs have cumulative effects, we need to monitor what happens in the soil over many years. In addition, climate change is leading to less predictable weather patterns. Understanding the long-term impacts of different management practices requires longer-term research projects. Having stable, long-term funding and research infrastructure, similar to the approach taken with livestock research facilities, would produce more results and attract research talent to the soil health discipline.

Such a framework would facilitate:

- Verification of soil degradation diagnostics;
- Site-specific soil health BMP verification;
- Baseline and on-going monitoring and practical research of soil health and environmental outcomes in real-time and real-farm conditions;
- Refinement of detailed soil health assessment methods;
- Training of soil health assessment staff and partner service providers; and
- Demonstration farms – for tours and informal education regarding soil degradation and effective, and site-specific soil health BMPs.

**Long-term trials** allow researchers to evaluate the effects of best management practices on soil through many different weather, climate, pest and weed pressures. A study published in 2014 from the Ridgetown campus of the University of Guelph showed that over 11 and 15-year periods, adopting no-till practices with a winter wheat rotation improved the quality and storage of carbon and nitrogen on clay loam soils.

Gathering feedback from farmers who try new methods of production based on research results is just as important as getting the results to them in the first place. Fostering a strong communications loop between scientists, extension experts and farmers would make for a more robust research and learning environment and boost the drive to improve soil health.

It will also be important to work with indigenous peoples and learn from their traditional knowledge of the land.

**Proposed Actions**

- Integrate identified soil research priorities into research programs, distribute to other research organizations.
- Target funding for longer term research projects (>3 years), recognizing it takes a long time to see changes in soil health.
- Explore long-term funding of cropland research platforms for soils research infrastructure that includes land allocations and long-term access, analogous to livestock facilities (similar to the Elora Dairy facility).
- Strengthen industry, government and inter-jurisdictional research collaboration and leverage resources to advance shared soils research priorities.
- Continue development of the Soil Health Interpretative Centre at Elora Research Station as a knowledge hub.
- Increase knowledge transfer and communication with farmers through research facilities.
- Explore the role of research facilities with the demonstration farm network.
- Develop a protocol document on what data is needed and how to collect soil data in collaboration with Ontario Soil Management Research Services Committee and researchers.
- Ensure basic soil data is collected from all long term research trials and other research plots and housed in a central, accessible database.
Scientific rigour and practical applications combine for a triple win

On-farm, farmer led research is a great way for farmers to find out if an alternative way of producing crops is compatible on their farm and profitable, and provide useful results from which other farmers can learn. It’s a win-win-win situation for farmers, soil health and increasing our knowledge in ongoing efforts to protect and build soil health. The Ecological Farmers Association of Ontario (EFAO) and Ontario Soil and Crop Improvement Association (OSCIA) are two examples of organizations helping to make this happen.

EFAO supports farmers through helping to design the experiment and write a research report and how to conduct robust scientific research. OSCIA has ongoing, multi-year applied research projects supported through their Tier Two grants.

With the research that is happening on plots and farms, there is a huge opportunity to collect data and house it in a central database, which could be made easily accessible to researchers. We heard that people are willing to collect these data during their research but they need to know what data is most useful and how to collect it.

Decision Making

In order to have a meaningful impact, we have to understand what informs farmers in their soil management decisions, the ways people learn most effectively, and the real barriers to soil care. Behavioural science, social marketing and adult education are developing new and innovative ways to understand and influence learning.

Proposed Actions

- Complete and build on studies on farmers’ motivations, learning styles, target audiences (commodity groups, etc.) to inform program approaches.

Communication Tools

The way that people learn and communicate has changed rapidly over the past decade. Social media such as Twitter and YouTube has become a mainstay for many people and agriculture is no different. It is now common practice for farmers to consult the Internet for short videos, share information and listen to podcasts for information and advice.

Ontario has numerous publications such as our Best Management Practices series booklets and in print or electronic form, this information can be used to develop smaller-sized print media (i.e., Soil Health Infosheets), training materials and other complementary media – such as videos, twitter messaging, etc. An integrated approach to using complementary media (print, e-media, and communication vehicles) is a more effective approach to reaching and motivating Ontario farmers to improve their soil health.

Proposed Actions

- Increase the variety of communication tools used to connect with farmers, including optimizing the use of interactive maps, mobile technology and social media in addition to print materials.
- Create an online go-to information resource hub for farmers where they can get the latest knowledge, research, go-to-apps, etc.
- Develop a series of videos profiling farmers and practices.
- Deliver webinars and podcasts to share local and broader expertise.
Tech Transfer

Digital learning is an effective tool, but there also needs to be other, more personal ways for farmers to stay on top of soil health advancements. This could include a mix of training sessions for individual farmers, more peer-to-peer learning opportunities, and courses for farm workers.

Since we know that farmers learn best from other farmers, offering more opportunities for peer-to-peer knowledge transfer and visiting demonstration sites would help increase both the awareness and uptake of practices that build healthy soil.

There are a number of soil health champions in Ontario sharing their experiences with other interested farmers. For example, a new organization called the Ontario Soil Network, is piloting an approach for coordinating these efforts. This group of leading-edge farmers is working to improve their soils, hone their communication and leadership skills, and share their messages about effective soil health practices with their farm neighbours and colleagues. Many organizations are also championing soil care including the Innovative Farmers Association of Ontario, the Soil Conservation Council of Canada, Grain Farmers of Ontario, and Ontario Soil and Crop Improvement Association.

Farmers also require access to technical assistance, whether it’s from a Certified Crop Advisor, an OMAFRA specialist, or someone from their local Conservation Authority. We need to ensure that these technical experts also have access to soil knowledge and training.

Proposed Actions

- Increase hands on-soils learning for farmers at workshops and training sessions.
- Establish, fund and support peer-to-peer learning groups.
- Build capacity among farmers as champions and advocates for soil health to speak with their peers about the issues and challenges of soil health.
- Build capacity for one-on-one technical expertise with service providers.
- Establish a demonstration farm network across Ontario for best practices:
  - Convene a workshop to kick-start planning and implementation.
  - Create a webpage to highlight locations and activities of demonstration farms.
- Develop further training for users of soils information and interpretation (e.g. agronomists, planners, foresters, contractors, CCAs, staff, innovators).
- OMAFRA work with partner organizations to help them develop soil-health focused workshops.
**Education**

Colleges offer technical soil courses for a variety of programs with different applications, including agriculture and resource management.

University undergraduate programs train many soil professionals in practice and can provide general soil knowledge to a broad range of professionals. The Canadian Soil Science Society Education Committee reviewed soil science education and found the need for introductory soil courses at several major universities.

Graduate education programs at universities help deliver knowledge on soil research priorities and develop advanced knowledge and skills in soils. Currently, OMAFRA offers a Highly Qualified Personnel program to graduate students, which includes a semester of hands-on work along with their courses. In addition, post-secondary students have been able to take advantage of the Ministry’s soil intern program.

Research priorities focusing on soil health will help to foster soil care knowledge and skills development among graduate students.

A recent Canadian Soil Science Society review confirmed the need for a greater emphasis on soils in secondary schools. Sustaining action on soil health in the future will depend on having people who are interested, engaged and knowledgeable about its many benefits – people who care about our soil. This involves teaching our youth about soils and how crucial they are for growing the food we eat and keeping our environment healthy.

**Proposed Actions**

- Engage universities/colleges in review of technical skills and knowledge needs, current courses/programs and develop strategies to address gaps.
  - Explore options to build soil science, including pedology, and skills into courses
  - Explore course options including online courses, new field courses, co-operation across Canada for some course content
  - Create more opportunities for on-farm experiences for graduate students and foster greater two way communication between farmers and students.
  - Consider new courses related to skills inventory requirements revealed in the review.
  - Consider new soil internships in government, industry and farm organizations.
  - Assess the need for revised and/or additional materials to support elementary/secondary education related to soils.

**Learning about soil**

- AgScape is an Ontario organization dedicated to providing resources and teacher ambassadors to teach children in grades 1 to 12 about agriculture and food production.
- The Canadian Society of Soil Science provides soil education resources for secondary school teachers through its ‘Soil 4 Youth’ program.
- 4-H, a youth development organization, offers a “Loyal to Soil” project to members, who are aged six to 21.
Building on Our Momentum: A Future Ontario Soil Health Collaboration

Federal and provincial governments, farm organizations, conservation groups and universities have a long history of working collaboratively on soil conservation and agri-environmental initiatives. Inspired by similar models in the US, OMAFRA and the working group are proposing that a longer-term collaborative approach and governance structure be considered, involving interested working group organization members, and possibly other organizations. The model would build on the group’s accomplishments, ensure collective momentum is maintained over time. This group would help guide and monitor implementation of the strategy during 2018-2030. Changing how we view the soil, not as an inert substrate but a living ecosystem, requires profound collective effort, not just tinkering with existing approaches.

The establishment of such collaborations would ensure that the profile of agricultural soil health in Ontario remains elevated, and that our approaches. It allows our efforts to continuously improve, based on the best available science, technology and knowledge. It would also facilitate alignment of effort, leveraging the activities of different groups with shared objectives, generating higher value returns on the human and financial investments of all involved.

As we have shown, there are many soil champions in Ontario – including those who directly manage the soil and those who support the managers of soil. Harnessing their collective energy and know-how to keep driving this initiative would help build and sustain Ontario’s agricultural soil for generations to come!
Conclusion and Next Steps

Building and maintaining healthy soil over the long term will strengthen Ontario farmers’ and society’s ability to prosper, help feed not only ourselves but people around the world and safeguard the environment.

Ontario has a strong foundation – our province is made up of willing and capable people and organizations in the public and private sectors who are deeply committed to advancing the soil health cause.

By examining and monitoring the soil, as well as adopting the latest technology and making new knowledge available to farmers, we can counter the harmful effects of erosion, low soil biodiversity, nutrient depletion and even climate change.

The Draft Ontario Agricultural Soil Health and Conservation Strategy (2018-2030) provides a framework for conserving and improving the land which provides our necessities of life and farmers’ livelihoods, over the long term.

Now, we’re inviting you to weigh in. Please provide your thoughts, comments and advice on what we’ve developed, to help shape our final strategy and guide soil stewardship activities in the coming decades.
How to Participate

We welcome you to provide your feedback on this draft strategy. We encourage you to complete a brief survey, at www.surveymonkey.com/r/soilstrategy.

You may also connect with us via the Environmental Registry posting by visiting www.ebr.gov.on.ca and entering posting number 013-1373, or by e-mailing comments to SoilHealth@ontario.ca.

Comments will be received until December 30, 2017.

All comments are welcome, but we ask that you consider the following questions as you respond:

• What soil health and conservation issues matter most to you?

• Which issues or actions should be the highest priority in the next few years?

• Do you have any suggestions for improving the proposed actions and the strategy?

• Which of the strategy’s actions do you see yourself or your organization contributing to and how? Do you support establishing a collaborative group (made up of government, farm organizations and other partners) to oversee the implementation and adaptive management of the strategy? What should its role be and what key needs could it serve?
Appendix 1 – The Agricultural Soil Health and Conservation Working Group

To guide development of the soil strategy, in 2015 OMAFRA brought together the collaborative Agricultural Soil Health and Conservation Working Group – made up of knowledgeable people from farm organizations, agri-food businesses, academia, conservation organizations and the federal government. They were instrumental in developing the 2016 discussion document and this draft strategy. The working group’s understanding of the issues has been invaluable. The group will continue to support this project as it evolves toward a final strategy. Continued collaboration with our partners will be essential to support implementation of the strategy.

Soil Working Group partners

- Ontario Federation of Agriculture: Don McCabe
- Christian Farmers Federation of Ontario: John Bos
- Agriculture and Agri-Food Canada: Maxine Kingston
- Ontario Soil and Crop Improvement Association: Andrew Graham
- Conservation Ontario: Tracey Ryan, Grand River Conservation Authority
- Universities and Research Community: Ralph Martin (University of Guelph), Claudia Wagner-Riddle (University of Guelph)
- Ontario Certified Crop Advisor Association: Dale Cowan, CCA
- Ecological Farmers Association of Ontario: Ken Laing
- Soil Conservation Council of Canada: Don Lobb
- Innovative Farmers Association of Ontario: Laurent (Woody) Van Arkel
- Farm and Food Care: Sam Bradshaw
- Grain Farmers of Ontario: Josh Cowan
- Ontario Fruit and Vegetable Growers Association: Harold Schooley
- National Farmers Union Ontario: Tony Straathof
Appendix 2 – Actions at a Glance

All of the proposed actions in the draft soil strategy are listed below. These actions would be implemented collaboratively by all soil care partners such as farmers, federal and provincial governments, conservation authorities, farm organizations, researchers and agribusinesses.

Soil Management

✔ Expand the development, enhancement and promotion of the suite of soil BMPs and their adoption.

✔ Identify and address barriers to the adoption of BMPs, both general barriers and specific barriers for individual BMPs.

✔ Government and farm and commodity organizations explore opportunities to grow markets for crops such as hay, cereals, perennial biomass crops, etc. that support diversified crop rotations. Each can incorporate relevant objectives in research, business and market development activities.

✔ Promote, research, adapt and support the adoption of conservation tillage practices such as no-till and strip till.

✔ Led by Grain Farmers of Ontario, the Ontario Cover Crops Steering Committee will implement the Ontario Cover Crops Strategy to encourage widespread adoption of cover crops on farms in Ontario.

✔ Promote, develop and support use of cover crops through a range of tools including awareness, education and incentives.
✔ Promote, develop and support the use of organic amendments.

✔ Explore opportunities for web based tools for locating and accessing organic amendment material.

✔ Promote both agronomic and structural erosion control measures and help landowners find the most suitable and effective combination of each for their fields.

✔ Develop erosion assessment tools that can be used with existing planning tools to provide landowners with ways to determine long-term erosion control benefits or consequences of their management choices (also see Expansion of Soil Erosion Assessment Tools).

✔ Raise awareness of the risks of compaction with farmers, agri-business and equipment dealers and manufacturers.

✔ Help farmers assess their compaction risk, based on their soil type, equipment type and weight, and traffic frequency and patterns, to help them identify ways to reduce the risk.

✔ Examine opportunities to improve soil-related aspects of the Environmental Farm Plan, GLASI Farmland Health Check-Up and Lake Simcoe’s Soil Health Check-Up.

✔ Examine opportunities to expand the availability of the Farmland Health Check-Up and Soil Health Check-Up tools to other parts of Ontario.

✔ Develop a detailed soil risk assessment tool to help interested farmers dig deeper to further understand their soils, and the risks associated with them, and make plans for improvements.

✔ Expand enhanced cost-share funding (like the Great Lakes Agricultural Stewardship Initiative and Soil Health Improvement Program) for soil BMPs to across the province.

✔ Support on farm trials for farmers to start small, try new practices and demonstrate ‘proof-of-concept’ on their farm (e.g. a small grant funding program).

✔ Encourage willing farmers to test and adapt innovative methods in soil health through a specific category of grants to allow the innovators to try new practices to benefit soils.

✔ Examine the potential of other agriculture programs to encourage good soil management practices through enhanced eligibility requirements.

✔ Support the development of carbon offset protocols that align with soil health priorities; soil health research findings will help inform the protocol design.

✔ Develop and implement initiatives that encourage management practices which reduce net greenhouse gas emissions while benefitting soil health, under Ontario’s Climate Change Action Plan.
Soil Data and Mapping

✔ Continue inventory and mapping to complete provincial coverage of a next generation soil resource inventory and maps over a 20 year cycle.

✔ Continue updates to the land suitability for agriculture classifications, under the Canada Land Inventory system, to assist in management decisions; longer term, investigate the development of a next generation land suitability rating and suitability systems that builds on the existing Canada Land Inventory system.

✔ Complete targeted LiDAR coverage for farmland in Ontario as a foundation for soil mapping, BMP tool development and land resource initiatives.

✔ Establish a technical/advisory committee to advise on priority areas for soil mapping and LiDAR data acquisition.

✔ Make existing and next generation soil data available on a publicly accessible, digital platform.

✔ Identify business requirements and develop a business case for the development of a Soil Information System.

✔ Determine best practices for standardizing data collection, storage and maintenance and metadata records.

✔ Explore ways to use remote sensing data for collection of soil characteristics, information and analysis.

✔ Explore tools such as airborne or hand-held sensors that can assess soil physical, chemical and biological properties.

✔ Engage stakeholders in discussion – how to move toward greater accessibility of soil test data.
  • Explore how to address privacy issues, roles of labs and clients.
  • Explore data sharing partnerships among multiple partners.
  • Examine collaborative arrangements for data sharing among federal, provincial and territorial governments and stakeholders.

✔ Work with Ontario Agri-Food Technologies and others to explore data use and sharing from precision agriculture.

✔ Complete an initial project to assess the state of soil-related agricultural practices and establish baselines from which to measure change.

✔ Compile existing information such as Census, Farm Environmental Management Survey, existing remote sensing data (e.g. AAFC annual crop inventory), aggregate soil test data, BMP adoption data.

✔ Establish a partnership with Statistics Canada for in-depth analysis of data on select practices.

✔ Identify data gaps and baselines to measure change in practices over time.
Soil Evaluation and Monitoring

✔ Create and distribute a farm-level, all-in-one education tool kit for soil health assessment that extension staff and farmers can use. This could include slake tests, infiltration tests, and soil compaction measurement.

✔ Work with the Ontario Soil Management Research Services Committee and laboratories to explore opportunities for a more consistent approach to soil organic matter analysis across the province.

✔ Promote the importance of soil organic matter as a way to monitor soil health.

✔ Develop and implement an Ontario soil health test in collaboration with laboratories over the next five years.

✔ Expand OMAFRA’s and partners’ capacity in soil erosion assessment:
  • Enable development of tools to estimate soil erosion under different management practices (e.g. like ‘Soil Calculator’ or equivalent)
  • Continuously improve/maintain these erosion assessment tools as new approaches become available (e.g. integrate and verify the recently developed gully erosion estimator with RUSLE2 to provide land managers with better estimates of sheet, rill and gully erosion rates and to assess the effects of different practices on controlling these rates).

✔ Explore the potential to ensure continuation of existing monitoring and expand watershed soil health assessments to other watersheds.

✔ Incorporate consideration of soil health and conservation in water quality assessments (e.g. sub-watershed plans) where possible.

✔ Adapt the AAFC soil indicators to a more refined scale.
  • Explore options to calculate indicators at more detailed scale (e.g. apply algorithms to more detailed soil maps)
  • Assess data on management practices at detailed scale (Census)
  • Explore greater federal-provincial collaboration on indicators
  • Examine adaptation of specific set of indicators for Ontario including soil organic carbon, erosion risk, soil cover

✔ Examine options to track and report on changes in soil carbon.
  • Options include continued participation in the development of a Global Soil Organic Carbon Map, Ontario’s Land Use Carbon Inventory development, AAFC soil organic carbon indicator and analysis of soil test data from labs
✔ Adopt the following long-term provincial desired outcome targets:
  • Increase soil organic carbon - reverse the decline in soil organic carbon and stabilize or increase soil organic carbon over time
  • Reduce soil erosion risk - lower risk of erosion and area of cropland in higher risk categories over the long term
  • Increase soil cover - by increasing cover crops, perennial crops, residue
✔ Using the existing AAFC soil indicators and any subsequent adapted indicators to track improvements in soil organic matter, erosion risk and soil cover.
✔ Promote farm-scale soil organic matter targets for soils of different texture:
  • Sandy Soils: 2.5%, Sandy Loams: 3.5%, Loam Soils: 4%, Clay Loams: 4.5%, Clay Soils: 4.5%
✔ Promote the following practice-based targets as suggestions for farmers:
  • Crop rotation: At least 3 crops in a rotation (for annual cropping systems)
  • Cover crops: 50% of a farm's annual cropland have a cover crop
✔ Evaluate changes in benchmarked soil profiles across the province on an ongoing basis to monitor changes on the landscape / effects of cultivation on soil profiles (through the soil inventory and mapping).
✔ Examine the potential for ongoing monitoring of permanent soil plots across Ontario. This could include examining the potential for expanding the number of permanent plots to adequately cover the range of soil, climate and cropping systems for Ontario.

Soil Knowledge and Innovation

✔ Integrate identified soil research priorities into research programs, distribute to other research organizations.
✔ Target funding for longer term research projects (>3 years), recognizing it takes a long time to see changes in soil health.
✔ Explore long-term funding of cropland research platforms for soils research infrastructure that includes land allocations and long-term access, analogous to livestock facilities (similar to the Elora Dairy facility).
✔ Strengthen industry, government and inter-jurisdictional research collaboration and leverage resources to advance shared soils research priorities
✔ Continue development of the Soil Health Interpretative Centre at Elora Research Station as a knowledge hub.
✔ Increase knowledge transfer and communication with farmers through research facilities.
✔ Explore the role of research facilities with the demonstration farm network.

✔ Develop a protocol document on what data is needed and how to collect soil data in collaboration with Ontario Soil Management Research Services Committee and researchers.

✔ Ensure basic soil data is collected from all long term research trials and other research plots and housed in a central, accessible database.

✔ Increase the variety of communication tools used to connect with farmers, including optimizing the use of interactive maps, mobile technology and social media in addition to print materials.

✔ Create an online go-to information resource hub for farmers where they can get the latest knowledge, research, go-to-apps, etc.

✔ Develop a series of videos profiling farmers and practice.

✔ Deliver webinars and podcasts to share local and broader expertise.

✔ Increase hands-on soils learning for farmers at workshops and training sessions.

✔ Establish, fund and support peer-to-peer learning groups.

✔ Build capacity among farmers as champions and advocates for soil health to speak with their peers about the issues and challenges of soil health.

✔ Build capacity for one-on-one technical expertise with service providers.

✔ Establish a demonstration farm network across Ontario for best practices.
  • Convene a workshop to kickstart planning and implementation.
  • Create a webpage to highlight locations and activities of demonstration farms.

✔ Develop further training for users of soils information and interpretation (e.g. agronomists, planners, foresters, contractors, CCAs, staff, innovators).

✔ OMAFRA work with partner organizations to help them develop soil-health focused workshops.

✔ Engage universities/colleges in review of technical skills and knowledge needs, current courses/programs and develop strategies to address gaps.
  • Explore options to build soil science, including pedology, and skills into courses
  • Explore course options including online courses, new field courses, co-operation across Canada for some course content
  • Create more opportunities for on-farm experiences for graduate students and foster greater two way communication between farmers and students.
  • Consider new courses related to skills inventory requirements revealed in the review.

✔ Consider new soil internships in government, industry and farm organizations.

✔ Assess the need for revised and/or additional materials to support elementary/secondary education related to soils.
Appendix 3 – Proposed Ontario Soil Health and Conservation Research Priorities

The following represents the top soil health and conservation research gaps and priorities in Ontario. These priorities were identified by a variety of agricultural organizations and reflect the most pressing demands from a production, environmental and scientific standpoint. These priorities were put together by OMAFRA staff, academic and AAFC soil researchers, experts and industry representatives.

Two events were held to identify soil research priorities and discuss knowledge transfer related to soils, a Soil Health Research Forum held November 28th, 2016 and a Soil Health Research Workshop held April 26, 2017. These events respectively gathered together key practitioners in soil conservation and the top soil researchers (University, AAFC and private sector) to discuss the key issues and research topics for soils in Ontario.

Continuity of Research Funding

In recognition that it takes time to be able to measure soil health change, it is important to have long-term funding for soil health research.

- Commit long-term funding for soil health research and plots (basic plot maintenance and operation i.e. land, labour, equipment).
- Create a category of research funding for longer fixed term projects (i.e. multiple rotation cycles).

What Research is Required?

Soil Health Indicators

In order to measure and track our status for soil health, it is important to determine key measurable soil health parameters. The indicators can be used to help manage soils for improved soil health.

- Identify key indicators or functions for the chemical, physical and biological aspects of soil health at the local, regional and provincial scale.
- Develop a clear list of robust measureable soil health parameters.
- Develop soil health management tools that utilize soil health indicators and assist growers with implementation of soil health BMPs.
• Validation of applicability of site-specific data to larger scales (watershed, province).

Physical

Soil physical properties that are most often researched include: soil structure/aggregate stability, soil strength, soil porosity and hydraulic properties. Soil physical properties are influenced by and have influence on chemical and biological properties. They can have an influence on crop growth from a micro to a macro scale.

• Quantify the impact of land management on soil physical and hydraulic properties and their influence on soil health (including resilience):
  • Diverse crop rotation (three or more crop families (legumes, non-legume broadleaf, warm and cool season grasses) in rotation) with and without perennial crops (i.e. forages), cover crops (i.e. oats, radish, mixtures).
  • Effects of tillage (a continuous type of tillage such as no-till, or strip tillage or rotational tillage where several types of tillage are used in the crop rotation)
  • Effect of crop residue removal for biomass or other uses where with and without other compensating management practices, what are sustainable residue removal rates
  • Specific cover crop species (includes precision management where specific species may be used for a specific purpose in the crop rotation or in part of a field)
  • Soil compaction

Biological

Soil biology links the chemical and physical aspects of soil health; however it remains the least studied. The study of biology within soil is a significant undertaking due to the complexity of the subject and the potential costs.

Farmers are very aware that their soil is alive; that it is an ecosystem in itself. There is growing interest in soil biology and the links to soil productivity and resilience, particularly in the face of a changing climate. It is critical to make direct connections between on-farm practices, best management practices and soil biology research.

Soils are complex ecosystems with a wide variety of organisms and often a degree of redundancy in that there are usually a series of organisms that perform the same or similar functions (for example, nitrogen mineralization).

• Development of tests/indicators for key functions in healthy soils for on-farm testing and validation
• Development of a soil health test (suite of tests) calibrated to crop production response for Ontario soils (similar to the calibration of fertility tests)
• Document and validate the soil biology related links between soil health BMPs (such as crop rotation, cover crops, organic amendments) and production response across:
  • a variety of production systems common in Ontario (field vegetables, grain, perennial horticultural systems)
  • Representative soil textures and inherent soil quality (such as sands, clays, shallow soils)
  • A variety of weather conditions and climate extremes

Chemical

The impact of soil health practices on fate (crop uptake, retention and loss) of nutrients in cropping systems, regardless of source (soil, fertilizer, organic amendments, crop residue, etc.) must be
measured. Priority nutrients include N, P, K, S and trade-offs and unintended consequences should be considered when conducting such a systems analysis.

- A better understanding of the return on investment of adopting soil health practices in relation to nutrient input requirements. For example, determine the impact of enhanced soil health on fertilizer recommendations and critical soil test levels (e.g. for phosphorus and potassium).

- The efficacy of best management practices to reduce loss of nutrients (N and P) from agricultural land while maintaining productivity.

- Best practices to optimize plant nutrient use efficiency and economics of nutrient application (e.g. 4R nutrient stewardship).

- A better understanding of nitrogen availability from soil organic matter, organic amendments (manure, biosolids, compost, etc.) and cover crops (legumes and non-legumes) – in terms of amount released and synchronization with crop uptake.

- Determine impacts of crop rotation effects on nutrient management strategies (timing, placement, etc.)

- Determine the impact of soil health and 4R nutrient stewardship practices on greenhouse gas emissions (e.g. nitrous oxide).

- Develop decision support tools for farmers / agronomists:
  - how to adapt their nutrient management practices to extreme weather events.
  - to predict amount and timing of nitrogen immobilization as a result of application of high carbon: nitrogen organic material (e.g. high carbon manure source or high carbon cover crop) - how does a producer adjust inorganic N inputs & timing of application?

Chemistry alone is not enough to provide good information on soil health; it is necessary to integrate soil chemical measurements with those from other disciplines.

**Research Project Structure and Management**

A systems approach is encouraged for soil health research. The greatest advances for any one project have come when it has a variety of expertise (e.g. physics, chemistry, microbiology) all working together. This may mean having more intensive studies, as opposed to having ten different sites with many unanswered questions. Farmers should be an integral part of the project development process and on-going review and revision.

- Encourage a multidisciplinary approach to soil health research, which considers the production system.

- Develop interdisciplinary collaboration to establish soil health baseline datasets from a soil ecosystem perspective and linked to crop productivity and economics to document how management changes soil health.

- Involve farmers in research project development and management decisions.

**Baseline Data**

In addition to research priorities, the research community found it is imperative to collect a common set of baseline soil parameters at research sites; and to also create a mechanism to facilitate data sharing.

- Create a list of soil parameters (e.g. soil type, soil organic carbon, etc.) and methodology for use by those conducting research to collect baseline soil data.

- Develop decision support tools for farmers / agronomists:
  - how to adapt their nutrient management practices to extreme weather events.
  - to predict amount and timing of nitrogen immobilization as a result of application of high carbon: nitrogen organic material (e.g. high carbon manure source or high carbon cover crop) - how does a producer adjust inorganic N inputs & timing of application?
• Develop soil landscape information to guide or optimize soil sampling and make these data available and easy to access.

• Sampling needs to be long-term, not project-based, need financial commitment from an organization to maintain sites.

• Create and update baseline maps of soil properties. Explore the potential for creating a coordinated network of voluntary sampling on a regular base.

**Data Sharing**

In light of the increase in precision agriculture data collection, limited research funds and increased collaboration at multiple locations, data sharing is a high priority.

• Establish a working group to facilitate this (sharing agreements, value of data, end use of data, where to store, who would house it).

**Economics**

Farmers experience the costs of implementing best management practices (BMPs) and the return in crop value today, while the benefits from improving soil health accrue over the long-term. This can make it challenging to sell the benefits of implementing practices to improve soil health without knowing the loss of value from erosion or the economic benefit of implementing BMPs.

• Evaluate the economic impact of physical soil degradation.

• Conduct a cost / benefit analysis of BMPs as it relates to crop productivity, profitability and sustainability.

• Develop methods to quantify economic aspects of soil health.

• Integrate economics as a deliverable for project funding where applicable.

**Behavioural science**

What factors influence farmers’ management choices in cropping and soil management (e.g. short or long term economics, social norms, family and social relationships, convenience, management experience, perceptions, beliefs, impulses, etc.)? While these topics have been studied in depth in other jurisdictions, relatively little research has occurred within Ontario to inform policy and programs. Sociology, psychology, neuroscience, social marketing, and behavioural economics are revealing that decisions by farmers and all of us are influenced by many surprising, often non-rational factors. Differences among farmers in motivation and other factors can influence adoption of practices significantly.

Research is needed in Ontario on factors that affect farmers’ decision making and contribute to, or detract from, soil management behaviour change. Differences in needs and barriers among farmers (e.g. commodity, part-time/full-time, off-farm income) should be identified. Research can also test strategies to address these needs and barriers.