Greenbelt Farmers: Sustaining Soil Health

Headlands Ag-Enviro Solutions

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Greenbelt Farmers: Sustaining Soil Health
Prepared by Headlands Ag-Enviro Solutions

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Introduction

Recall that whatever lofty things you might accomplish today, you will do them only because you first ate something that grew out of the dirt. — Barbara Kingsolver

Soil sustains life on earth. A thin layer of topsoil, the earth’s skin, gives us our food while also cleaning our water and air. Formed over millennia, it can be lost in a matter of generations if we don’t treat it carefully. The quality of soil determines the quality of our food and the quality of our life. So how we grow our food and build our cities makes a world of difference.

At over 2 million acres, Ontario’s Greenbelt stretches from Niagara to Northumberland. The Greenbelt offers permanent protection some of the province’s most productive agricultural land and a wealth of important ecological systems.
From the clean air and water that sustains human life to the natural beauty of the landscape that provides recreational opportunities, the Greenbelt is uniquely positioned to provide and preserve a high quality rural and agricultural landscape for the benefit of millions of Ontarians. Protecting and conserving the rich diversity of soils that are found in the region is critical to sustaining the Greenbelt over the long-term. In this report, we will learn about fifteen outstanding farm families in the Greenbelt and the innovative ways they protect the soil. Our challenge, as a society, is to support a food system that will work for today while preserving soil for tomorrow. We are all a part of the solution: farmers, eaters, scientists, and policy-makers alike.
The History of Soil and Farming

Many types of soil exist across the world, but they are all essentially mixtures of tiny pieces of rock, decayed plant material, air, water, and microbes. The variations in soil type depend on factors such as the mineral composition of the ‘parent’ rock, how the rocks were weathered and what particle size they became, and whether it was formed from the bedrock below or was blown or washed in from somewhere else. The size of the particles (clay, silt, or sand) and how they are layered on each other determines the type of soil, which determines how well they will hold on to water and nutrients to support plant growth.

History of Greenbelt Soils

The Greenbelt includes the Niagara Escarpment running north and south and the Oak Ridges Moraine running east and west, along with large tracts of various soil types in between. The area was formed under lakes, glaciers, and forests over millions of years.

The Niagara Escarpment is not a fault line; the 725-kilometre-long ridge was formed by erosion. The entire Great Lakes region was once under water and layers of sediment formed on the bottom of the lake over time. Fragments of shells settled in a long strip, which formed a dolomitic limestone layer. Limestone is more resistant to erosion than other rock so, as the glaciers and water retreated, this strip acted as a ‘cap’ and protected the rock beneath it. It created a basin which now holds Lake Erie, Huron, and Michigan. The layers of sedimentary rock are visible from the iconic rock faces of the Escarpment, most notably the 50-metre high Niagara Falls, though the ridge can reach up to 500 metres in some places.
The Escarpment in turn influenced the Oak Ridges Moraine, a 160-kilometre-long ridge that developed between two lobes of the Wisconsin Glacier as it retreated about 10,000 years ago. Water flowed in this glacial channel and deposited sand, rocks, and gravel nearly 200 metres thick in places. It created a boundary between Lake Iroquois (what would later drain to be Lake Ontario) and Lake Algonquin (Lake Huron and Lake Michigan).

When rain falls onto this ridge, it infiltrates through wetlands, oak forests, and kettle ponds. It is both filtered and stored by sand and gravel aquifers, creating springs and streams throughout the area. The Moraine has been called “Ontario’s Rain Barrel” – its huge water storage capacity gives rise to 64 different streams and rivers, including the Credit, Humber, Don, and Nottawasaga Rivers. In all, over 200,000 Ontarians drink from water that originates in the Oak Ridges Moraine.

Between the Escarpment and the Moraine, the Greenbelt’s agricultural land consists of soils primarily laid down during the retreat of the last glacier. Some of these soils were deposited by the retreating ice; these soils can be gravelly, and often contain larger rocks. Richer clay soils built up on the bottoms of these now-gone lakes made areas of excellent farmland within the Greenbelt. This topsoil is relatively thin but is some of the most fertile in the world.

**Understanding Soil Biology**

Apart from their long geological history, soils also vary based on climate and the types of micro-organisms that live within them. Hidden beneath our feet are communities of billions of bacteria, fungi, protozoa and other tiny living things that make all of life on Earth possible. They decompose plant and animal waste to recycle their nutrients and they extract rock minerals to feed to plants. Without this biology, soil would be just tiny bits of weathered rocks, lifeless and barren.

When we walk across a lawn, over a farm field, or along a forest path, we are treading on the rooftops of hidden communities of soil micro-organisms. These mysterious communities, like our own societies, are complex, dynamic, diverse, and highly structured. Micro-organisms, like us, have jobs in mining, trading, farming, nursing, communication, housing construction, and defence, etc.

- Mining: microbes extract minerals from both organic matter and rock and then trade these resources to plants in return for energy foods that the roots provide;

- Farming: soil insects shred plant and animal matter, increasing its surface area so that microbes will live there, then they consume these micro-organisms;

- Construction: fungi construct houses in the soil by wrapping themselves around clumps of soil to build structures – this benefits the microbes, but also the plants.
These basic soil functions have long been known to scientists, as well as to many farmers, but the complexity, diversity, creativity, and power of the soil community doesn’t end there. Scientists are beginning to understand that plants can communicate with each other through the strands of fungi, warning each other of outside threats. And that smaller organisms, like bacteria, hitchhike on larger ones to get to where they need to go. Plants partner with certain bacteria to form an alliance in which the bacteria protects the plant from disease in exchange for food. We are just beginning to unravel the mysteries of what happens in those complex communities beneath our feet.

Soils are living ecosystems, and what we call healthy soils are soils that have a healthy community of organisms. The living creatures that make up these soil communities, as well as the relationships between them, are often referred to as the soil food web. The members of this web range from microscopic bacteria to easily visible insects and earthworms. Moreover, just like above-ground ecosystems, the soil food web is a hierarchy, based on who eats whom.

At the base of the food web are two very different types of organisms: bacteria and fungi. Both are microscopic, although you can see fungi when their strands mass together (those white strings you see in a decaying log), or when they make ‘fruit’ as mushrooms. Both bacteria and fungi are very important to decomposition and to healthy soil.

Bacteria are the tiniest: you could fit 100 million or more on the surface of one of your fingernails. They are also quite simple, compared to larger organisms. But their small size and simplicity are a bit deceiving, because they have some of the most important jobs. There are three main types of bacteria:

- **Decomposers:** these bacteria get their energy from eating non-living plant and animal matter. If you’ve ever wondered how food waste breaks down in a compost pile, it is because of these bacteria. They recycle waste back into nutrients that plants can use and they leave stabilized organic matter (humus).

- **Pathogens:** these bacteria get their energy from living things and can make plants and animals (and us!) quite sick. Of course, they are still part of a healthy community, but these pathogens must be kept in balance.

- **Mutualists:** these bacteria get their energy from plants, and they pay for their food by trading the plants for nutrients. The most well-known example in farming are the rhizobia bacteria that live on the roots of legumes, such as alfalfa, peas, or beans. They are able to make nitrogen from the air in the soil and they give it to the plants in return for food.

Fungi can be grouped in the same three categories when it comes to where they get their food energy. Fungal decomposers also get their food by breaking down organic matter, but they specialize in breaking down harder-to-decay woody materials. This is why forest soils have much more fungi than bacteria, while grasslands are more evenly balanced between the two. As with bacteria, there are many types of fungal pathogens, like smuts, blights, and various other fungal diseases. Finally, the third category of fungi are mutualists and they are called mycorrhizal fungi, which means ‘fungus roots.’ They partner with plant roots to trade important nutrients, such as phosphorus and nitrogen with plants in return for food.

Protozoa are little creatures, bigger than bacteria but still microscopic, that swim around in soil water and eat bacteria - and they eat lots of them. Nematodes are microscopic worms, a little bigger than protozoa, which also swim around eating things. Some nematodes eat bacteria, others eat fungus, and some eat...
smaller organisms such as protozoa and smaller nematodes. One particular type attacks plant roots, which makes it a major agricultural pest; however, the vast majority of nematodes are beneficial to plants.

These micro-organisms are found everywhere in the soil, but especially around the root areas. Plants secrete sugars and carbohydrates from their roots as food for fungi and bacteria. Protozoa and nematodes, which eat bacteria and fungi, also stay close to these root zones. As they eat the other microbes, protozoa excrete rich plant food (think of them as microbial manures), right where the plant roots are able to quickly absorb them. This ancient circle of life, this give-and-take, forms the fundamental basis for soil fertility.

The other creatures of the soil food web play a role in the soil fertility story as well. Micro-arthropods (such as insects and spiders) chew plant and animal matter and reduce its size, making it more available to fungi and bacterial decomposers. Earthworms sit at the top of the food web mixing the soil, transporting bacteria and fungal spores to new areas of the soil, and increasing soil fertility with their wastes, which are full of beneficial bacteria.

These soil microbes are critical to fertilizing plants naturally. Healthier plants mean healthier food and healthier people. Healthy soil also helps the environment by creating structure in the soil to improve water infiltration and water quality and pulling carbon out of the atmosphere.

### Soil Structure

Soil structure is created when the glues secreted by soil organisms, mainly bacteria, fungi, and earthworms, cause small particles of soil to clump together. These small clumps are then woven together into larger clusters by the threads of fungi and the tiny hairs that grow from plant roots. When you pull a plant out of healthy soil you will see lots of these crumb-like ‘aggregate’ clusters hanging from the roots. These aggregates are the key to carbon and water management in soils. Because they are large and irregular in shape, they resist being compacted when walked or driven on, and have lots of pore spaces like sponges. These pore spaces allow both air and water into the soil where they benefit plant roots and soil microbes.

When it rains, healthy soil will absorb water and it will filter through the soil to recharge the water table below. This improves water quality and regenerates aquifers, ensuring clean water for the next generation. Without this clumpy sponge-like structure, soils become compacted. Compacted soils cannot absorb water, so run-off and flooding results. This also deprives soil microbes of essential moisture which increases the severity of droughts and creates soil erosion and water quality issues. Water management will be a growing concern with the extreme weather predictions in the future.

Soil is also an important carbon sink and scientists believe that building healthy soil is one of our best hopes – not only in adapting to climate change but mitigating it, as well. Living plants pull carbon from the atmosphere and push it out through their roots to feed the microbes. Much of the carbon-rich food is converted by soil microbes into stable forms of carbon (called soil organic matter) that can be stored in the soil for decades if not disturbed.
One of the major issues for soil health, however, is that the agricultural soils are routinely disturbed through tillage. Every time it is disturbed, the threads of the soil food web are broken and will take time to regenerate. Tillage also releases the carbon that is stored in the soil into the air. Not only in Ontario but around the world as well, soil has been losing its organic matter in this way. Without adequate levels of organic matter, farmers must increase their use of costly synthetic fertilizers and pesticides until the point is reached where soils are so depleted that they can no longer support reasonable yields. Building up, or regenerating, levels of soil organic matter will depend on the widespread implementation of many of the farming practices described in this report, all of which support the growth and resilience of the tiny creatures of the soil food web.

Who is Responsible for Soil Conservation?

Don Lobb, P. Ag.(Hon) has had a long career in soil conservation. He began as a farmer in Huron County and was one of the earliest, successful no-tillers in Ontario in the 1980s. He worked with a multitude of university and government researchers over his 35 years farming. He was a founder of the Innovative Farmers Association of Ontario (IFAO) and a founding member of the Soil Conservation Council of Canada. He has been honoured for his lifetime efforts and achievements as an inductee of the Canadian Conservation Hall of Fame and the Ontario Agricultural Hall of Fame. He now lives in Caledon and continues to work as a consultant.

He also continues to speak and advocate for the importance of soil conservation. He points to the fact that soil test labs in Southern Ontario indicate that soil organic matter levels have dropped from about 6% to about 3.5% since 1950. “Each year, world-wide, we lose an area the size of Scotland to non-ag development and soil erosion,” says Don. “Canada contributes to that trend.”

He quotes David Montgomery, author of the book Dirt: The Erosion of Civilizations: “Soils are not lost because we farm – they are lost because of how we farm.” Surely, Don’s farming career demonstrates that improved farming practices greatly improve the quality of the soil without lost profitability.

But who is responsible to turn the tide? Don believes that we are all responsible, and he outlines the role that farmers, scientists, farmland owners, government, food processors and retailers, and society have. “Society has a responsibility to encourage and support strong soil care incentives and the protection of valuable foodland,” he says. “Society also has a responsibility to be informed – philosophy, perceptions and parochial agendas are not good enough when our food supply is at stake.”

“We all have work to do,” Don concludes.
History of Farming in the Greenbelt

When European settlers came to the area, Southern Ontario was already being farmed by Haudenosaunee and Anishinaabe communities, who cut and burned portions of the forest to cultivate corn and other annual crops. They would farm in an area for about a decade before moving to another location and allowing the forest to regenerate after they left.

Farming changed as European settlers slowly moved into the area and grew grains to ship back to Europe. Forests were cleared permanently, and the soil was turned over every year with the plow for annual crops. Farms were parceled out to settlers; over the next century, more land was cleared from the forest and wooden or clay tiles were buried in trenches to improve field drainage. These farms were ‘mixed farms’ that had a diversity of animals to provide milk, eggs, and meat for the settlers while they grew grain for export. Farm work was done by horses, so farms were small and included many fields of hay and perennial pasture for animals.

Over time, farms began to specialize. As tractors, new equipment, and commercial fertilizer became available and as the food processing industry changed, small mixed farms were no longer economically viable. Farmers needed more acres and more animals; they needed to specialize. Many farmers sold their land and moved to the city, while the rest began to concentrate in pigs, chickens, or dairy. Others sold their livestock altogether and specialized in growing just corn, soybeans, and wheat.

Some areas were more suited to fruits and vegetables. South of Lake Ontario, the proximity of the Niagara Escarpment to the lake creates a ‘bench’ effect, which is a micro-climate with warmer temperatures and good air movement. Over time, this area became dominated by vineyards and plum, cherry, peach and pear trees. This area is now designated as the Tender Fruit growing region. The Holland Marsh is also designated as a specialty crop area; this low-lying flat area to the southwest of Lake Simcoe was drained in the 1920s and 1930s, and farmers are able to produce incredible vegetables in the rich peat soil.

Farming has a big impact on the soil, and it can create concerns for water quality, climate change, and food nutrient density. But how we farm makes all the difference. Farmers and scientists are beginning to understand the biological systems needed to build soil and the farming systems necessary to support soil biology. Farmers in the Greenbelt are combining traditional farming wisdom with new technology to lead the way in soil conservation. As we will see in this report, these farmers face economic, technological, and social challenges that we can only solve together, as a society.
Bowman Family, Bowmanview Farm

Eric and Jenny Bowman and their family have been raising livestock all their lives on their farm near Enniskillen, east of Toronto. “We only have six inches of topsoil to work with,” says Eric. “If we don’t take care of it, we’re done.” The Bowmans believe that putting carbon back into the soil is the key and that it can be done through a systems approach. “It isn’t just one thing,” says Aaron. “It is everything together.” That means growing cover crops, minimizing tillage and including animals. They bring in organic mushroom compost and compost their own cattle manure in piles before applying it to their fields to build soil fertility naturally.

Farm History

Eric grew up on the 192-acre farm that his grandfather bought in 1929. He says that he always knew he wanted to be a farmer, and after graduating from the University of Guelph with an Honours Degree in Animal Science, he was determined to make it happen. He married Jennifer, a neighbour and a farm girl herself, in 1975 and they milked cows for three decades, surviving the 21 percent interest rates of the 1980s. In 2005, they switched to raising grass-fed Angus beef cattle and certified their farm as organic.

Bowmanview Farms covers a total of 300 acres and was run by Eric and Jenny, but is now in succession to their son Aaron and his wife Tasha and their kids. Aaron has a Master’s Degree in Crop Science and worked on the University of Guelph research farm for several years while he was a student. Truly a family affair, Bowmanview Farms doesn’t employ anyone else; they rely on each other to do the work. “Whoever can work, works,” says Aaron, who is also employed as an agronomist and seed dealer.
Over the years, Eric and Jenny met any challenge that came their way as a team. Jenny worked as a part time Registered ER Nurse at the Bowmanville Hospital, but also milked the cows and ran equipment. “We never got mad at the farm at the same time,” Eric says. “We kept motivating each other. The trick was that I was lucky to have married a girl with the same goals as I had.”

No one stays in one place too long at Bowmanview Farm. The entire family is driven to improve the farm and keep pushing the envelope by trying new things. “Our neighbour even jokes that when Jenny is tidying up the yard she will throw you in the truck that is headed for the dump if you are not moving,” says Eric.

**Farming for Soil Health**

The Bowman family had long worked to improve the environment by planting trees, protecting water and keeping pasture for their dairy cattle. They also paid careful attention to soil health and grew cover crops. But it wasn’t until the family saw a TED talk by Allan Savory that they had their ‘ah ha’ moment about grazing and its link to carbon sequestration. “That blew me away,” says Eric. “I now understand that we need to have split hooves on the soil.”

When Eric saw Savory’s talk, the Bowmans decided to make some changes on their farm, and they transitioned to high density grazing instead of letting the whole herd graze the entire pasture, selectively eating what they prefer and re-grazing an area before it has had a chance to recover. They now use portable fences to limit the herd to a smaller area, mimicking a herd on the prairie or savannah. In this system, cattle are in greater competition with each other, eat all the grasses, and trample the pasture more aggressively, before being moved to a new piece of the pasture. Aaron bought his dad a set of tumble wheel fences for Christmas one year and these have made the process of moving fences more efficient.
This grazing technique improves the pasture and grasses grow back faster and greener. Short grazing periods with relatively high stocking density, followed by long rest periods, allow the plants to recover from grazing and pump carbon into the soil through their roots in the process. In this way, rotational grazing regenerates the soil by increasing organic matter levels and improving water infiltration. This creates a virtuous cycle, more biomass, and better daily weight gains for the animals. Some of the Bowman’s fields are more than 6 percent organic matter and over the last years their soil tests have shown improvements.

The entire farm is surrounded by fences, laneways, and portable watering troughs to allow the cattle to graze fields all across their property. They graze pasture and the cover crops grown after they have harvested their organic grain crops. They even have their cattle grazing fields of standing corn. While Eric still cuts corn for silage in the winter, he loves to see the cows outside and enjoys bringing the cattle to the food instead of vice versa.

So, while soil health is important to their operation, they also do it for the labour savings. One of the issues with being an organic farmer is the amount of tillage that needs to be done to control weeds without herbicides. This often means driving a tractor up and down the field pulling a cultivator or scuffler up to six or eight times for each crop. This takes time and fuel, but disturbing the soil also releases carbon dioxide and harms soil microbes. The Bowmans do not follow this practice and are moving toward reducing tillage on their farm.

Allan Savory and Rotational Grazing

Allan Savory is an ecologist and farmer from Zimbabwe who observed, and then demonstrated, that herd animals are the key to reversing desertification. In Africa, grazing animals of all kinds stay in tightly packed herds due to the threat of predators. When they graze, therefore, competition from the animal beside them forces them to eat unselectively, which is good for maintaining plant diversity. They also trample excess biomass and their manure into the ground and leave hoofprints. On the surface it looks like a mess, but rainwater pools in their hoofprints and germinates seeds from their dung. In effect, these animals have started the process of reviving the grasslands for when, months later, they may come back to the area. Healthier grasslands mean that more rainwater will infiltrate and wake up the soil micro-organisms, which feed the plants, just as the plants in turn feed them. Not just in arid grasslands, but all over the world, lush green fields pull carbon from the atmosphere and store it in the soil, improving the soil, water, and air quality.
The Bowmans are on the forefront of an organic, low-till system that incorporates a cover crop to act as a mulch for weed control. Cereal rye is planted as a cover crop in the fall and terminated in late spring either by grazing, cultivation, or by using a front mounted crimper on the tractor with blades that crimp the stem of the plant and kill it mechanically. This becomes a thick mat that protects the soil and suppresses weeds. Aaron began roller crimping in 2016 and is gaining confidence by starting small and seeking the advice of others who have experimented with it in the United States.

In 2018, he grew a tremendous crop of soybeans, and he attributes the success to a few key factors. First, in the previous September, he broadcasted 100 pounds of cereal rye and ‘tickled’ the seed into the soil with a high-speed disc, instead of planting the rye in rows. Second, he waited until the cereal rye was well into its reproductive stage, far longer than other farmers have typically waited, before rolling it. Third, he modified his planter to have proper seeding depth and seed trench closing so that the soybeans had the best possible start.

“We did nine acres this year,” says Aaron. “And it is at the back of the farm where no one can see it driving by,” he laughs. He doesn’t recommend that farmers try this system on large acres but believes it will work well for smaller organic farms going forward. For them, the labour saving is key. “We planted that field on June 3 and didn’t touch it until we harvested,” he says.

“Do what is right for the soil, with the system and equipment that you have,” Aaron advises farmers. As an agronomist, he works with both organic and conventional farmers and he believes that both have their place and can benefit the soil. “We have drawn a line in the sand between the two systems, and there really shouldn’t be one,” he says.

To Eric, another benefit and indicator of soil health is clean water leaving their farm. He doesn’t want to see soil erosion and muddy water so a few years ago, he removed two acres from a field and created a grassed waterway to reduce erosion and improve water quality. “It creates a bit more work to mow it, reduces our workable land, and we still pay property taxes on it,” says Eric. “It is good for the environment though, and I think it would be an easier sell for farmers to put these waterways in if there was some tax relief at the very least.”

The Bowman family markets their beef directly to their customers, who drive to the farm to pick it up. Their customers like to see the herd and learn about how the animals were raised. The Bowman family loves to show them their farm. “I give them an experience and show them how their food is grown,” says Eric. “One of the biggest problems is that people are so disconnected from their food, and it is partly our fault as farmers. We are so busy producing some of the world’s safest and best food that we forget to teach the urban population what we are doing and how we accomplish our goals of soil preservation and food production.”
Larry & Marg Dyck, Campden Grain

At the heart of regenerative agriculture and soil health are the innovators. These are the people that wake up in the middle of the night wondering how they can improve their farming systems. They tinker in their shops on equipment, they humbly share their knowledge with their neighbours and, in so doing, they both lead and give back to their communities. They are not looking for kudos or recognition. In fact, the sign of a true innovator is someone who doesn’t even see themselves as one. From their perspective, they simply see a challenge and feel there is no other option than to do something about it.

All the farmers and families featured in this report are true innovators, but two of the most determined and modest are Larry and Marg Dyck. The couple, along with their son Ben and daughter-in-law Kait, grow grain on 2300 acres of heavy clay soil located between St. Catharines, Grimsby, and Smithville. For years, Larry had been growing cover crops and trying to minimize tillage, but he had an ‘ah ha’ moment at a SoilSmart conference in 2015, which has since driven him to the forefront of no-till planting into cover crops in Ontario.
Farm History

Larry’s father purchased the home farm in 1951 and he bought the first tractors to be used on the farm, replacing horse-drawn farm implements. Since then, things haven’t stayed the same for very long. Without the need to feed horses, most farmers cultivated their perennial pastures, growing annual crops instead of grass for feed. Similarly, Ontario farmers used to raise many types of animals, but over time were forced by economics to pick one type of livestock to specialize in, or alternatively to focus just on crops. For many years, the Dyck family focused on pigs. But it was hard work in the barns, and being so close to a rapidly urbanizing area, they were concerned their neighbours would complain about the odour. In 2009 they sold the pigs and changed their focus to corn, soybeans, and wheat.

Farming for Soil Health

“After I sold the pigs, I wasn’t sure how I could keep soil organic matter levels up,” says Larry. Livestock is critical for sustaining soil; spreading animal manure on fields feeds soil microbes, builds soil organic matter, and provides a natural slow-release fertilizer.

Larry’s question was answered at the SoilSmart conference, in which American soil scientist Ray Archuleta, who speaks with the passion of a Southern Baptist preacher, explained how the understanding of soil had recently been turned on its head. “We always thought that soil grew plants,” Archuleta had said. “But only recently we’ve started learning that it is plants that grow soil.”

He demonstrated how planting crops to cover the ground between corn, soybeans, and wheat could protect the soil from erosion and increase the soil’s fertility, structure, and biological activity. “Listening to Ray helped me understand how cover crops could help the soil as a green manure,” says Larry.
He has since planted multiple species of crops together after harvesting wheat. His mixture consists of oats, radish, turnips, pearl millet, sorghum sudan grass, phacelia, sunflowers, sun hemp, faba beans, hairy vetch, crimson clover and Austrian winter peas. Each plant has a different benefit for the soil. Radish and turnips drill deep in the ground with their tap roots to break up compacted sub-soils. They die after the first frost, leaving behind holes in the soil for better water infiltration. Phacelia and oats have finer roots that break up top-soil compaction and improve the structure of soil, while the faba beans, vetch and clover naturally produce nitrogen in the soil to benefit the subsequent crop. Planting such a diversity of cover crops provides a buffet for microbes and also provides a sort of insurance: in a part of the field where one species doesn’t do well, a different one will. Getting an even cover of plants means that weeds don’t have an opportunity to grow and infest the field.

Wheat is harvested mid-summer, which leaves plenty of time for cover crops to grow in the fall. But in Larry’s rotation, wheat is only grown every three years, so he is innovating to have cover crops after corn, as well. Because Ontario has a short growing season, it is most often too late to plant cover crops after corn is harvested. Instead, Larry does ‘interseeding’ and plants the cover crop in the field just after the corn is planted to give it a head start. While fertilizing the corn with nitrogen when it is about knee-high, he also plants rows of clover, radish, and ryegrass. When the corn stops growing in the fall and the cobs mature, more light gets to the ground and these cover crops start to grow. They can protect the soil during harvest and on through the winter and spring.

Cover crops can be difficult to plant correctly and are very dependent on the weather. “In 2016, there wasn’t enough rain to plant into the corn in June and we just left the cover crop seed in the shed,” says Larry. But the next year, there was so much rain after the wheat was harvested in August that they weren’t able to drive in the field for a month. “We couldn’t collect soil samples, let alone plant a cover crop,” he adds.

Keeping living plants growing is one of the most important ways to build soil health because plant roots feed the microbes in the soil. However, another important way to improve soil is to not disturb it. In most of the world, fields are plowed or cultivated every year to kill weeds and to loosen the soil to plant a crop. But every time the soil is disturbed, the networks of beneficial fungi in the soil are, essentially, forced to reset.

No-till planters were developed in the 1960s in the United States. They were designed to have a lot of down-force in order to put seeds into harder ground and to cut through crop residues on the surface from the previous year. These no-till planters became quite common in the 1980s, at a time when farmers were facing a debt crisis and needed to minimize costs. By not having to pull tillage equipment, farmers saved fuel costs and time.
Larry tried no-till planting corn in the 1980s but didn’t have much success; his clay soils stayed too wet to allow him to plant in good time. Ten years later he tried again, planting soybeans using a no-till planter rented from his county’s Soil & Crop Improvement Association. After a few years of renting, he purchased his own planter and gradually minimized the frequency and intensity of tillage. Finally, he stopped tilling altogether.

Larry has now taken no-till and cover crops to the next level and is doing what only a few innovative farmers have dared to try. Most farmers will kill a cover crop with tillage or by spraying in the fall or early spring, but Larry wants to have his field covered as long as he possibly can. To do this, he is planting his corn and soybeans into a living cover crop; he is ‘planting green.’ He purchased and tinkered with a planter that can roll and crimp a standing cover crop and also has enough down-force to plant right into it. The dead cover crop, rolled over, crimped, and lying on the ground, keeps the soil cooler, feeds microbes, and stops weeds from growing.

Larry and Marg even tried ‘planting green’ in their vegetable garden this year. They rolled a tall crop of cereal rye flat to kill it, planting their garden into the mulch. Gardeners know that weeds will grow if the ground isn’t covered and growing mulch ‘in situ’ has many benefits year-round.

Now in his third year of planting green, Larry feels more confident. “The first two years, I had to rely on crop insurance because the corn yields were low,” he says. “But, to be fair, the drought was so bad in 2016 that nearly everyone around here was in the same boat.” Even this year, his corn has had varied levels of success, largely based on the amount of rain it received. On his land near Smithville, there was a good rainfall after planting, but the fields near the lake got no rain, so the cover crops stole moisture from the corn. “Weather is the biggest challenge for any farmer,” says Larry. “And until we figure out how to plant this way, we really can’t fault the system.”
Another challenge for the Dyck family is the heavy clay soil that they farm. They estimate they would need drainage pipes every few feet to be effective, but that isn’t feasible. “Without good drainage, it is difficult to go no-till or to plant cover crops,” says Larry. “But, on the other hand, I am starting to see that no-till and cover crops naturally improve drainage.”

“I’m motivated to do all this out of supreme irritation with this clay soil,” Larry laughs. “I always wondered if there was a better way we could farm and if we could improve soil and water quality, so I’m trying. When I pull the planter into a field of green cover crops, I feel like I’m doing something meaningful. The world is watching.”

“We don’t have our neighbours making fun of us for trying something new,” Larry adds. “We’re all struggling to farm here with the same kind of soil, and they are watching what I’m doing to see if it might work for them too. We talk about tweaking rates of fertilizer or tillage, but what is actually making the difference in the soil? If the soil is really as alive as they say, then the microbiology impacts us a lot more than just tweaking our phosphorus rates.”

Still, Larry wonders if he might be getting too far ahead of farmers in the rest of the province. The financial incentive programs that are run through Ontario Soil & Crop Improvement Association (OSCIA) help farmers purchase the equipment needed to plant cover crops and reduce tillage, but they don’t reimburse farmers who have already made the purchase before the program was available. “If I had waited a year until the program was announced, I would have got some money back,” says Larry. “Every bit counts, because in the end we have to be able to pay the bills in order to keep doing this. But, if we had waited for the program to catch up to us, we would be another year behind in this learning process.”

Larry jokes that he farms in the ‘I-states.’ Not Iowa, Indiana, and Illinois but the I-states of mind: idealist, idiot, etc. Still, joking aside, it seems obvious that Larry doesn’t see in himself another obvious I-word: innovator. Yet, with enthusiasm and humility, he and his family are firmly at the forefront of soil-focused innovation in Ontario.
Kyle Horlings, Kettle Creek Farms

Kyle Horlings is conserving soil in the Holland Marsh; in Ontario, there’s no place quite like it. Before it was developed for agriculture, it was a large wetland lying within the valley created by the Holland River. Starting just west of Highway 400, near Schomberg, the Marsh follows the river northeast up to where it empties into Cooks Bay, at the southernmost tip of Lake Simcoe. For centuries, vegetation in the giant bog slowly decayed underwater and mixed with soil brought from further upstream, until metres of peat soil developed. In the 1930s canals were built to drain the area, turning it into 22,000 acres of highly productive vegetable-growing farmland. Farmers are still removing tree stumps from fields, some of which are over 2000 years old. The soil is black and loose, with extremely high levels of organic matter (between 40 and 80 percent), which act as a sponge for water and nutrients.

Farm History

The Horlings family, originally from the Netherlands (and therefore no strangers to farming close to the water table), came to the Holland Marsh to clear and drain it in the late 1930s. At that time, small 5-acre parcels of land supported farm families who grew a great diversity of vegetables for market in Toronto. Over decades, however, the grocery stores consolidated, and so did the farms. The Marsh area began to specialize in carrots and onions. Machinery became more advanced and the area relied more heavily on off-shore labour.
But the equipment, scale and markets are not all that has changed. Drainage and cultivation exposed the peat soils to oxygen, which speeds up the decomposition of organic matter; essentially, the soils begin to shrink as they release their carbon more quickly. To minimize this, drainage systems were adapted to allow controlled flooding of fields in the non-growing season. But Marsh soils are also highly susceptible to wind erosion, creating dust storms in the winter and spring especially. Over the last decades, several feet of Marsh soil have been lost to subsidence and erosion.

Kyle Horlings, 30 years old, is now the fourth generation ‘muck farmer’ in his family. He is growing onions and carrots in partnership with his father, within 5 kilometres of where his great-grandfather originally started. He and his wife Carolyn have a one-year old daughter.

**Farming for Soil Health**

Firmly rooted in the history of the Marsh, Kyle is pioneering a new way of managing soil and plant diseases. He is now ‘resting’ the soil every three years and planting cover crops as an alternative to using chemicals on the soil. In the 1980s, Kyle’s father Dave had felt that the soil was getting ‘tired’ from producing crops year after year, so he had rested the ground by growing a crop of sorghum sudan-grass, which mimics the native marsh grasses. After a few years of rotational resting, he felt that he had built the soil back enough to do continuous cropping again.

The concept of resting fields isn’t new but, in the past, we may have gone about it wrong. Generations ago, farmers across Ontario practiced fallowing, which means leaving the soil bare and cultivating it multiple times in a season or spraying it repeatedly with herbicides. They believed that by eliminating both crops and weeds, the soil could rest, store moisture, and absorb energy from the sun. We now know that leaving soil bare has the opposite effect: it starves the microbiology and degrades soil. Soil needs to be covered in green growing plants in order to truly rest and regenerate.

In 2014, Kyle took a page from his dad and began to implement a rest year of cover crops, planted after the onions are harvested. He started with a rye crop and the next year he tried something completely new to the area: mustard. Along with other plants from the brassica family (think arugula and kale), mustard produces a chemical compound called glucosinolate, which gives it a bitter and spicy flavour. This compound also acts as a natural pesticide: it kills pathogens in the soil that cause disease, eliminating the need for commercial fumigants.

Kyle admits that his crop rotation is still a work in progress. In 2017, he planted rye after the onions were harvested in late September and then planted mustard directly into the rye in the spring of 2018. In July, when the crop is typically high in moisture and just before the mustard had reached full bloom and started to produce seed, Kyle mowed and chopped the crop into pieces and immediately incorporated it into the topsoil. This must be done quickly, because research estimates that 80 percent of the mustard ‘gas’ will be released within 20 minutes, says Kyle.

After two weeks to let the plant material break down, he planted a crop of pearl millet, sorghum, sun hemp, mustard and radish. These plants also have ‘bio-fumigant’ properties. Kyle mowed, chopped and tilled this crop into the soil before planting a cover crop of radish. This radish dies over the winter and leaves little residue on the soil, so that he can easily transplant onions the following spring.
In another field, Kyle tried planting buckwheat. Buckwheat grows very quickly, making it useful to suppress weeds, but it has other benefits as well. It builds fertility and its flowers are excellent for bees and other pollinators. Farmers have long known that buckwheat improves soil but have been wary to plant it because it goes to seed so quickly and if it gets out of control it can become a weed in subsequent years.

A more common cover crop in the Holland Marsh is barley. Onions and carrots are planted with a cover crop of fast-growing barley between the rows which helps to protect the soil from wind erosion as the small onions and carrots are growing. The barley is terminated before it starts to shade out the vegetables and after they have enough size and root structure to keep the soil in place. Farmers have been doing this for decades, though even Kyle was skeptical. “We wondered if it actually helped prevent erosion, but after the one year that we didn’t plant the barley, we paid for it,” says Kyle. “We haven’t skimped on that cover crop since.”

Similarly, Kyle thinks it is only a matter of time before more farmers try to grow mustard as a cover crop and leave rest years in their crop rotation, especially now that the local Conservation Authority is helping to reimburse farmers for their seed costs. He notes that already he has been joined by another Marsh farmer. “It is difficult to wrap your head around a whole year without making any income off of a field,” says Kyle. “But we think that in the long run, with higher yields because of improved soil health, we can make it pencil out.”

As for barriers to improving soil health, Kyle says the biggest hurdles have been knowledge and equipment. He studied agriculture at the University of Guelph’s Ridgetown campus and only learned about farming ‘highland’ soils. Farming in the Marsh is unlike farming anywhere else: ‘highland’ soils can be anywhere from 1 to 6 percent organic matter, while peat is 40-80 percent. It is treated differently, and it acts differently, but there isn’t very much research done on peat anywhere in the world. The University of Guelph has a small Muck Research Station with a few staff just down the road from Kyle’s farm and he works with researchers there.

When it comes to cover crops, Kyle has been connecting with other farmers at conferences and finding information about them online. He first saw the mustard bio-fumigant used by a potato farmer growing in the sandy soils of Norfolk county. He has then worked to adapt the systems for muck soil. The typical equipment used for planting cover crops aren’t even available in the Marsh, so Kyle had an additional challenge to purchase and modify equipment.
It is too early to tell exactly what long-term impact Kyle is having by growing cover crops and giving the soil a rest year, but he can already see changes in the colour and smell. “It is darker and smells fresh and alive,” Kyle says. “Soil that is dead is dull grey and smells sour. It gets waterlogged and blows away more easily too.” Still, Kyle is not leaving anything to chance. He is taking soil samples to test for fertility, microbiology and diseases while tracking yields and quality to both better understand and to demonstrate to others how this cover cropping system works.

For Kyle, farming has always been in his blood. Despite the hard work and stress, he wouldn’t want to be anywhere else than working alongside his family. To Kyle, improving soil health means that he will have a future farming in the Marsh.
Joanne Feddes, La Primavera Farms

While the trend of the last fifty years in agriculture has been to move from mixed farms towards bigger and more specialized ones, some farmers have managed a different strategy by diversifying into niche products. Joanne Feddes of La Primavera Farms produces chickens that are raised without antibiotics (RWA), grass-fed Scottish highland cattle, soybeans, corn, wheat and cut flowers. Her 300-acre farm near Dundas is a model for diversity and sustainability.

Farm History

“I always wanted to be a farmer,” says Joanne. “I love everything about it, from baling hay to driving tractors.” Joanne comes by her love of farming honestly; she grew up on the same farm she now operates. Her father bought the property in 1954 and it was a dairy farm until the 1990s, when he moved towards the cut flower business. “I think it was a way to keep his four daughters occupied and out of trouble,” laughs Joanne. She is the only one of her siblings to have stayed on the farm and, currently, she operates La Primavera Farms with part-time help from her father and husband, a full-time farm manager, five full-time seasonal workers and a variety of student and part-time winter greenhouse workers.
Farming for Soil Health

The three main principles to build soil health are reducing tillage, increasing plant cover and applying manure. Joanne uses all three principles of soil health in combination with each other: growing cover crops after annual grains and grazing them with cattle, adding composted chicken manure to the fields, and reducing tillage. Joanne is an innovator and optimist, but she is also a pragmatist. The economic sustainability of the farm must be first and foremost. Farmers joke that if they aren’t careful, they can save the soil but lose the farm.

A small herd of cuddly-looking Scottish highland cattle are outside most of the year, with Obama the llama protecting the younger calves from coyotes. They are temporarily fenced into fields to graze on cover crops of oats and rye that she plants after wheat is harvested in August. This is one of the best ways to build soil, because the cattle convert the ‘green manure’ of cover crops into a far superior product: actual manure. Cattle break down grasses in their (four!) stomachs, with the help of specialized gut microbes, and the nutrients they drop in the field are just what the soil needs. Even in the winter, cattle love to be outside and Joanne keeps bales of hay in the pasture for them to eat, though cows often will dig through the snow to find grass in the winter.

Chicken manure is composted in piles behind the barn for six months, when possible, before being applied to fields. The composting process is important because microbes begin the process of breaking down the manure so that when it is applied to the fields, it is more mature, the nutrients are more stable, and the odour is greatly reduced.

Cut flowers are another substantial part of the farming business. La Primavera Farms wholesales sunflowers, peonies, ammi varieties, ornamental kale, bachelor’s buttons and many more. They custom-make gorgeous centerpieces and bouquets for wedding and events with an in-house floral designer. They also sell at farmers’ markets. Joanne is currently trialing about 300 roses, hoping to find new varieties that can thrive in this part of Ontario. She grows tansey around the edges of the flower beds to deter the Japanese beetles and she has also tried using a small flock of turkeys to eat the beetles that get in among the flowers.

Joanne has had challenges, like most farmers, making no-till planting work because weeds can be a major problem. No-till sunflowers take much longer to mature and this is a major concern when the timing of flower blooming is so critical. Cover crops have also been a challenge: one year the buckwheat flowered and reproduced so quickly that it became a weed; another year, clover frost-seeded into wheat in the spring led to the seeds being washed down the hill in the next rainfall.

Joanne is an innovator and optimist, but she is also a pragmatist. The economic sustainability of the farm must be first and foremost.
These challenges, however, don’t stop her from experimenting and innovating. This year, she tried planting corn without tillage into a living cover crop on a few smaller fields and had great success. In order to let the cover crop have as much time as possible to grow and benefit the soil, some farmers are trying to plant corn and soybeans directly into the cover crop while it is still green and growing (planting green), and then terminating the cover crop with an herbicide after planting. It keeps tillage and soil erosion to an absolute minimum and can also save costs as well. But, it can go wrong if the weather isn’t ideal.

Joanne was pleased with how the ‘plant green’ corn turned out and is eager to try the next step, which is to terminate the cover crop mechanically, without the use of an herbicide. She is hoping to rent a roller crimper in order to try it on her farm. A roller crimper is a heavy cylinder mounted in front or behind a tractor that rolls the cover crop down but also crimps the stem with a blade. This kills the plants and prevents any re-growth that would compete with the commercial crop. Roller crimping has been done by a select few growers in Ontario, and the understanding of timing and technique is still in its infancy. Innovative farmers like Joanne are driving the development of new practices and technologies that will eventually make farming for soil health the norm in Ontario.

Joanne joined a pilot project of the Ontario Soil Network in 2017-2018 that brought together some of the most innovative farmers in the province, so they could learn from each other’s experiences. She learned from farmers who had been no-tilling and planting cover crops for decades, but she is also committed to sharing her practical experience with other farmers who look to her for advice.

La Primavera Farms is diverse and resilient. Because Joanne has maintained the ‘mixed’ operation with livestock and a diverse crop rotation that includes flowers, she is building soil health at the same time that she makes her operation less vulnerable to the ups and downs of various commodity markets. She sees soil health as one area that can be a win-win for agriculture and the environment. However, for this to happen, she believes that all of us - farmers, politicians and the public - will need to see things a bit differently.
Kottelenberg Family, Labora Farm

Of the close to 5,000 farms in the Greenbelt, no two farms will be run the same, because every farm operator has different attitudes, values, and knowledge. Each also has their own specific type or types of soil, their unique access to land and capital, and different influences that drive their decision making. Bernie Kottelenberg farms near Caledon with his wife Joanneke and children, but he also works as a financial advisor with many types of farms and farmers. His economic perspective has led him to promote farm-drainage investments, such as permanent grassed strips that protect the soil by preventing erosion.

Farm History

One of seven kids, Bernie grew up on a dairy farm near Hillsburgh and studied agricultural business at the University of Guelph. He worked for a number of banks after he graduated and, in working with both large and small farms across the province, he saw that a key success factor was the attitude of the farm owners. “By listening, observing and working with them, I gained some valuable insights into the business side of farming from various successful managers. Careful use of capital was a lesson I learned from my own father,” says Bernie. “And I was inspired to start out on my own.”

In 2002, he took the plunge to start his own farm. “There are a lot easier and quicker ways to make a
living,” he says. “But this is the lifestyle that we wanted, working together where we live, as a family.” He and Joanneke found the long-standing McPhee farm for sale, only a few kilometres from where Bernie grew up. It had light soil on slightly rolling terrain, an old cattle barn, and a new hog barn on the property, along with a large house that would soon be filled with their nine children. While they knew it was a difficult step for the current owner to sell, they saw the opportunity as providential for their growing family.

“When we started, the only equipment we had was a wheelbarrow,” laughs Bernie, who used his parent’s equipment for the first five years. His parents had sold their cattle and quota in 1998. “There wasn’t really a vision of how to pass the farm to the next generation,” he continues. But for Bernie, the next generation is already something he thinks about. “I’m sure not all of them will want this lifestyle, but a few of them might,” he says. “And I want to give them every opportunity I can.”

In 2010, Bernie and Joanneke saw there would be a unique opportunity to start milking cows and they took another calculated leap. They converted the old-style ‘bank’ barn to a dairy barn and accessed cows and quota as an early participant in the New Producer Program. They now milk 54 cows and farm 300 acres.

Their oldest son, Caleb, is nineteen and is also studying agricultural business at the University of Guelph. But he has already purchased 20 percent of the shares into the cropping business with his dad, grandpa, and uncle. “For me, it was important to put some skin in the game,” says Caleb. “It is extra motivation to get up early in the morning, because I’m working for myself and not for someone else.”

**Farming for Soil Health**

When the Kottelenbergs bought the home farm, they noticed a 3-foot deep gully in the field near their house. When it rained, water would flow into the low channel, picking up speed and washing out a long stretch of their sandy-loam topsoil. Year after year it was filled in, only to erode again, with tonnes of precious topsoil going down the drain, quite literally. It was bad for the farm, but also bad for water quality downstream. So, Bernie did the math and figured it would be worth an investment. “When you’re starting a farm with very little equity, you have to focus on doing the basics well,” stresses Bernie. And for him, soil is the most important asset to protect.

Bernie did an Environmental Farm Plan for his property and learned that he could access some funding to install a grassed waterway, which would permanently remove some of the area from the field, protect the soil from erosion, and make other areas of the field more productive. From his years of schooling and doing bank paperwork, Bernie didn’t shy away from filling out forms. In 2007, he worked with the Credit Valley Conservation Authority (CVCA), the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), and the Ontario Soil & Crop Improvement Association (OSCIA) to install a sub-surface drainage system upstream of the gully, along with a small berm and inlet that would take the surface water safely into an underground pipe so that it wouldn’t scour away the top soil. Then they graded a slight ditch, 200 metres long, and planted it in grass so that it could transport the remaining surface water to a second berm and inlet to take it underground, to eventually outlet in an existing waterway.

Now, a decade later, they continue to have great success with the project. They cut the grass within the ditch and clean out the inlets to keep the waterway functioning properly. They have virtually eliminated soil erosion from that area, greatly improving water quality downstream from the farm.
The waterway was so successful, in fact, that the Kottelenbergs constructed another one in 2015 on a different field. It is a 300-metre-long waterway which crosses two properties and draws a line in the middle of the field. A drainage pipe and a catch basin inlet (picture a street sewer grate in the city) takes surface water underground and outlets it into a wetland at the lowest end of the field. The existing wetland was enhanced 20 years ago by Ducks Unlimited and works to filter the water from the field while providing habitat for many types of birds and animals.

The Kottelenbergs are protecting more than just the low areas of the field. Their light sandy-loam soils and topography make the whole area quite vulnerable to erosion. Over the years, the family has tried planting various cover crops, such as clover after wheat, and rye after corn that has been harvested early for silage. For a dairy farmer, a cover crop of rye can also be harvested as feed for the cows in the fall or in the spring, too. Grown between the main crops, these ‘cover crops’ have roots that keep soil in place, but also help to build levels of organic matter, improving the health of the soil. Since healthier soil holds more water, this improves water quality and helps plants better tolerate the stress of drought.

Grassed waterways are planted with grass (obviously), but also oats and barley, which establish more quickly the first year, to offer erosion protection and keep weeds from taking over before the grass is established. If weeds overrun the waterway, they can start to become a big concern as they creep into the field, as well, and it takes a few years of work to keep the weeds back as the grass becomes more established. But, even afterwards, the waterway needs to be mowed, cleaned, and otherwise maintained in order to keep it functioning properly. This can be a challenge to farmers who have a never-ending list of chores to be done around the property, but the Kottelenbergs have made maintenance a priority. Though there is a time commitment for maintaining a grassed waterway, the Kottelenbergs believe that improving water quality is worth the investment, and they have completed other projects around the property to improve the water that leaves their farm.

Bernie encourages other farmers to look into the opportunities to partner with environmental organizations, though he understands that the paperwork and maintenance can be a challenge to some. Also, many farmers are wary of working with environmental groups as there may have been antagonism between them in the past. Perhaps the tension lies in the time horizons. While both farmers and environmentalists consider decades and generations ahead, farmers must also work year-by-year for sustainable profits to support their families and are faced with payments and costs that need to be met immediately.
“Agriculture is a long-term effort with short-term priorities,” Bernie continues. The crux of the issue is how to improve the environment in the long-term, without losing the short-term profitability that keeps the farm running. “This is where financial advisors and the rest of the agricultural industry, government and society come in,” says Bernie. “We need all parts of the system to come together to work on this.”

For Caleb, as a young farmer involved at the University of Guelph, he sees a bright future. “In class, we have plenty of discussion around sustainability and population growth,” he says. “It can worry some, but we have a lot of great people in agriculture working on ways to improve the industry and I think we can figure it out if we put our heads together.”

Bernie is a unique farmer, bringing together the passion for growing food and family with a sharp mind of financial investment. Investment is about giving time, effort, or money in hopes it will pay off in the future. For Bernie and Joanneke, it is about focusing on the basics and building up the most important assets to the future of their operation, the soil, and their children.
Reuben DeJong and his wife Rebecca are young, progressive farmers who consider soil health to be basic to their profitability, as well as their farm’s sustainability. They are at the forefront of a new wave of young farmers who are bringing cutting-edge technology to improving soil.

Farm History

Reuben began farming in partnership with Lyle Gallagher, a now retired farmer, seed salesmen and a family friend. They now farm corn, soy, wheat, edible beans, and canola on 1200 acres. They also do custom work for other farms, all within a 20-minute-drive. Reuben and Rebecca bought the property on which their house sits a few years ago and, at that time, it was made up of 15 fields criss-crossed with fence rows and was not drained. Since then, they have made it into one 170-acre field that is systematically drained throughout. This was a huge investment, but Reuben says that yields have increased dramatically.

The young couple farm the rolling hills of the Oak Ridges Moraine, the same ones that Lyle Gallagher has been farming all his life. Lyle’s father passed away when he was a teenager and he worked with his brother on their mixed farm once he graduated from the University of Guelph in 1971. They sold their cattle when the markets got too low and, when the high interest rates came in the 1980s, Lyle worked off-farm as a seed
salesman. He hired Theo DeJong to do some of the field work for him, and when Theo passed away he started a farm partnership with Reuben, Theo’s then-teenaged son. With Reuben taking over the farm, Lyle is happy to be the hired man now. “I didn’t have a plan for succession,” says Lyle, “so I’m happy how this evolved.”

Farming for Soil Health

Lyle is a strong supporter of Reuben’s innovation with precision agriculture and relay cropping. Lyle himself was an early innovator with reduced tillage and cover cropping. Tillage unearths stones in the field that can damage equipment and Lyle says he spent too many hours of his life clearing stones, so he was grateful when herbicides were developed to control the weeds. It meant he could leave the plow in the shed. He recalls seeding clover into wheat thirty years ago, and even broadcasting wheat into his soybeans at that time. When corn prices took a dive in the early 2000s, he aimed to reduce costs as much as possible. He decided to not do tillage or apply fertilizer that year, instead planting the corn right into a living cover crop of clover and relying on the pig manure he had spread earlier to provide the fertilizer. He recalls it was a great crop of corn and showed the neighbours that there were viable alternatives to conventional farming practices.

Lyle wasn’t aiming to build soil strictly for the next generation. His innovative farming saved him money year after year and it just made economic sense to him to keep soil in place. Reuben is continuing to push the envelope and now has technology at his fingertips. He has been no-till farming from the beginning with Lyle and now uses a variety of cover crops, including rye grass, fava beans, radish and red clover. Seeing what a benefit their system has, Reuben wonders why more farmers don’t make the switch. “When I talk to these ‘conventional’ farmers about it, they just say that they have always tilled, and they are not going to stop now,” Reuben says.

Still, he has many peers in the region who have switched to no-till planting over the years and use cover crops. In addition, he is very involved with his county’s Soil and Crop Improvement Association and is currently the President. He enjoys working with other farmers in the area; they can share ideas and results, so that not everyone has to make the same mistakes.
Over the past few years, farmers have got turned on to the potential of precision farming and Reuben has become a dealer for a data company called Farmers Edge. These companies are monitoring all the details on a farm, including yield, soil and economics, to help farmers understand how to treat each acre of their land with much greater precision. They create zone maps in a field to show variability and allow farmers to change their rate of seed and fertilizer metre-by-metre, to farm more precisely and efficiently. Reuben knows that they can be more profitable if they put their minds to it. It is just a matter of working smarter.

“Now we have an actual picture of what is going on in the soil, to a level of detail and practical applicability that we never had before,” Reuben says. “This is huge advantage and I am looking forward to going further down that road.”

He can’t emphasize enough how valuable good data can be to an operation. “Variable rate seeding pays off. If you put too high a rate of seed on poor soil, they don’t have enough nutrients so you get a poor yield. If you reduce the rate on that poor soil, each plant is better able to get the necessary resources and your yield goes up,” Reuben explains. “Everybody thinks that you just save seed this way, but you can actually get a yield bump.”

While corn and soybeans are two of the most profitable grains in Ontario, growing winter wheat is great for the soil. It is planted in the fall after soybeans and so it acts as a cover crop to hold soil in the spring, but also adds diversity to a crop rotation and an opportunity to plant cover crops after it is harvested in August. But with wheat prices and yields so low in Ontario, many farmers have a hard time justifying growing it. Relay planting might change this, however.

This is Reuben’s first year trying this innovative approach. Last fall he planted his wheat with a gap row and in the spring, he planted soybeans into that gap when the wheat was about knee high. The two crops grew together and when the wheat was harvested in early August, the beans got extra light and space to really start growing. Getting two crops in one year could make growing wheat profitable, but another key benefit of relay cropping is its diversity. If the weather isn’t great for the wheat, then the beans will do well, and vice versa. This year was a good learning experience, as the weather was difficult to manage. Reuben found that wheat takes so much moisture that there is nothing left for the beans. Going forward, their solution will be to only do the relay planting in fields with high organic matter and good moisture levels.

They tried relay cropping this year on 100 acres. People said they were crazy to do that much, but they think it is important to do enough to get a result that is both measurable and significant. Lyle is happy to see Reuben continuing to try things and believes that a good farmer should always be trying new and better ways to do things. “Just don’t bet the farm on it,” Lyle laughs.

“We missed the rain in 2018, so our first attempt at relay cropping wasn’t a huge success,” says Reuben. “But we did get a good wheat crop and we learned how to do it better in the future, so I guess that is a win.” This was the case for many of the farmers that tried relay cropping this year and missed the early summer rains, but most are keen to keep trying. The hope is that relay planting soybeans will make it more economical for farmers to plant wheat and to increase the diversity of crops grown, thereby improving soil.
Without livestock on their farm, the DeJongs don’t have an economic reason to grow hay or other perennial crops that improve soil quality. But that might change, with a potential RuBisCo processing plant planned for the Cobourg area. RuBisCo is an alfalfa-based protein that is being used to create a better, cheaper egg-white substitute for baking. Having a major market for alfalfa close to home will allow the DeJongs to grow this perennial legume as a cash crop, which is great for the environment because it fixes nitrogen and builds soil.

Reuben is very aware of the importance of soil organic matter and says that he can see all of this on aerial photos of the field. “You can pretty well draw a line on the field where the level of organic matter rises or drops. Here, that corn is good and on the other side of the line, it isn’t— that is where the organic matter plummets. And on a dry year, you can really see where the farming practices of the past 100 years have hurt the soil.”

But innovation hasn’t come without struggles. His original no-till planter did not cut into the ground properly and the closing wheels did not firm up the ground enough. So, last year he took a big leap to invest in a no-till planter. He qualified for a government grant through Ontario Soil and Crop Improvement Association to share some of the costs of the investment.

So far, the DeJongs are keeping the balance, protecting both the soil and their bottom line. Reuben believes this success is because he pays so much attention to the soil, not in spite of it.
Ben Caesar, Fiddlehead Nursery

Ben Caesar has taken a unique and small-scale approach to agriculture: he farms like nature, with nature. In 2010, the 40-year-old moved north with his wife Kelly to the small community of Kimberley, in the Beaver Valley, which is now a UNESCO World Biosphere Reserve. He began both a family and a nursery to grow edible perennial plants. “I love living here with such protected diversity,” says Ben. “And with this nursery, we’re further contributing to the diversity here.”

Farm History

Ben and Kelly bought a sloping 30-acre property that was once a cattle farm. Ben grew up in a small town and had been first introduced to the concept of perennial crops and ‘food forests’ when he moved to Guelph in 2003 and planted nut trees with a friend. “The positivity and vision of permaculture drew me,” he says. “It was the first thing that really struck me as a solutions-based reaction to the problems in the world.”

After years of studying permaculture philosophy and planting perennial edible gardens in his backyard, Ben realized how difficult it was to source some of these rare plants. The vision for this business came from a desire to make these plants more available and adapted for Ontario’s edible gardens.
Farming for Soil Health

The clay soils in this area of the Niagara Escarpment are difficult to manage, but after just seven years, he has already seen changes in the colour and feel of the soil. It may take several more years before soil tests are able to confirm what sort of changes have occurred in the fertility and microbiology in the soil. “When soil isn’t disturbed, fungal networks develop between the roots of different plants and can transfer nutrients,” explains Ben. “So, I plant comfrey and nitrogen fixing plants in one end of the garden and these plants can improve the soil and the plants in a broad reach around it.”

Perennials plants have deep roots and can bring up nutrients that have leached further down in the soil. When their leaves fall, or their above-ground portion decomposes over the winter, these plants are adding organic matter and nutrients to the top soil.

Working with natural systems is one of the key concepts of permaculture philosophy. “When the first explorers came to North America, they thought they were looking at virgin forests,” explains Ben. “But these forests were intimately used by the First Nations for food and were changed by them. A lot of conservationists would argue that we should leave nature alone completely, but then they are missing the opportunity to be a part of it. There is such abundant food growing in nature, if we only know what we are looking at.”

Most people will recognize rhubarb and asparagus as perennial crops, but Ben introduces his customers to a diverse range of new plants and flavours in his nursery and through his extensive demonstration garden for a pick-your-own salad. The nursery’s inventory includes alpine strawberry, autumn olive, Caucasian spinach, chicory, Chinese artichoke, comfrey, currents, daylilies, hascap, horseradish, hostas, lovage, lupin, mallow, mint, mitsuba, Welsh onion, sage, saskatoon berries, sea kale, skirret, mountain sorrel, St. John’s Wort, sweet cicely, thyme, Turkish rocket, and yarrow, just to name a few!

For Ben, going against the grain has had its fair share of challenges. “When I started here, I had no idea how to grow nursery plants in a greenhouse,” he says. In his first year especially, he was supported by a neighbour, Anastasia Sparling of Beaver Valley Flower Farm, and started growing in her greenhouse before he built his own. He learned how to propagate plants from cuttings, transplanting and seed collecting.

“Another challenge was that I wasn’t a good cook and didn’t know how to prepare all these perennials,” says Ben. “I had to learn how to use these plants from the garden and from foraging in the forest. But it has become more natural to me and now I cook with them every day.”
**Permaculture Philosophy**

Bill Mollison and David Holmgren coined the term ‘permaculture’ - or permanent agriculture - in 1978 and wrote two seminal books outlining the principles and practices. The term refers to both a farming and social philosophy. It is based on the authors’ practical experience, as well as the knowledge and wisdom found in books such as *One-Straw Revolution* (1975), by Japanese farmer Masanobu Fukuoka, and in the books and lectures of Ruth Stout. Both of these earlier writers advocated for ‘no-work’ farming using mulch instead of tillage.

Permaculture is all about design -- and being proactive. Solutions to potential problems are built right into the system, instead of being added after the fact. The core principles of permaculture are focused on observation and design, followed by implementation, interaction, more observation, and then taking the appropriate response. Creativity is highly valued, as are small, slow-to-unfold solutions. The principles place a premium on catching and storing energy, using renewable sources of energy and services, eliminating waste, and integrating the various components of a system, as opposed to segregating them.

Finally, permaculture also prioritizes the use of perennial plants. Perennials, by their very nature, promote healthy soils. Optimizing the use of perennials, while also creating better conditions for the farming of annuals and for protection of the environment, is the type of win-win scenario envisioned and practiced by permaculturists the world over.

After only a few years of growing Fiddlehead Nursery, Ben and Kelly’s yard is bursting with gardens, full of colour. He uses tarps to terminate the grasses and uses mulch and low-lying plants to keep the weeds down. Over time, he has noticed that the weeds are easier to control. The greenhouse, too, is full with nursery plants and with grapevines trellised inside. He sells his grapes at the Kimberley General Store and his farm is open to the public a few days a week; customers can sample the plants in his demonstration garden.

Another important practice in permaculture design is digging swales on slopes to manage water. By intercepting, storing or redirecting the flow of water, the risk of erosion is reduced, and water can be absorbed by the soil, enhancing plant growth on hillsides and recharging the water table. Ben dug contoured swales on the property and planted trees along them in order to ensure they could have adequate moisture. While often associated with permaculture, designing farms for water capture like this can be used at any scale and with various crops.

“I’ve also learned that plants can taste different if grown in different soil,” says Ben. “And that by creating micro-climates we can also affect the growth and the taste of some plants. Grown in the shade, there is a blanching effect that makes some things more tender or mild-tasting.”

Ben uses foraged and perennial plants to supplement his diet but doesn’t pretend that we can feed the world this way. “Of course, we still eat annual crops, but every perennial we can eat from helps minimize our environmental footprint,” he says. “Urban gardens are abundant with edible perennials too, like hostas and daylilies.” For Ben, permaculture helped him see food and farming in a new way and he is excited to share his passion with others.
Mike & Angela Scharringa, Dutch Mill Gardens

Mike Scharringa and his wife Angela bought Dutch Mill Gardens from his parents in 2014. They are the next generation of farmers in Ontario, who grew up with farming in their blood and technology at their fingertips. These farmers are embracing precision agriculture, using drones and remote sensing technology, GPS, and artificial intelligence on the farm. All of this is helping us better understand and protect soil resources.

Farm History

Dutch Mill Gardens produces field-cut flowers on about 450 acres of sandy-loam soil near Lynden. Mike’s parents, Ed and Elaine Scharringa, started growing flowers and vegetables on a 60-acre farm near Millgrove in the late 1980s, where they started a country market. They began to specialize in cut flowers in the 1990s, selling at the Toronto Food Terminal. Mike started to farm with them in 2002 and in 2008 they sold the Millgrove operation to expand near Lynden.
The home farm is now where they grow sunflowers in rotation with soybeans, along with a wide variety of cut flowers with subsurface irrigation lines and a compostable plastic mulch to conserve water. They grow sunflowers primarily, and a wide variety of cut flowers that they arrange on-site into ‘Taste of Country’ bouquets, which they sell to major grocery store chains. Mike and Angela, now proud parents to 6-year old quadruplets, work with Mike’s cousin Nick and forty seasonal employees who keep the place buzzing with field work, harvesting flowers, processing, and shipping.

**Farming for Soil Health**

Their sandy-loam soil is prone to wind erosion, especially in the winter when the ground is frozen, so Mike plants a cover crop of rye as soon as the flowers are harvested. He has also planted rows of trees to help control wind on the property. To improve soil fertility and increase organic matter levels, he buys chicken manure from his neighbours and composts the manure on his farm for up to a year before applying it to his fields, including the rented ones. By composting the manure, Mike ensures that the heat from the composting process kills weed seeds and pathogens. In addition, the compost will inoculate the soil with beneficial microbes that will make the soil’s nutrients more plant available, suppress disease and pests, and build good soil structure.

**Why Compost Manure?**

Compost can be made from virtually any organic material, including raw manure, crop residues, food scraps, and human and yard wastes. While composted manure is similar to raw manure in many ways, there are a few key differences. When composted, it does not leach as readily as manure, nor does it give off as many greenhouse gases, such as methane and nitrous oxide, when applied to fields. Compost is lighter and therefore cheaper to transport, its consistency makes it easier to apply evenly, and it doesn’t produce the unpleasant odours that raw manure does when applied. Finally, studies show that applying composted manure raises organic matter levels in soils more quickly than applying raw manure. But composting manure takes time and effort and doesn’t provide the quick boost of nutrients that raw manure does. If composted manure is meat and potatoes, raw manure is Red Bull.

Compost’s lower nutrient availability arises largely from the fact that the composting process changes the nature of whatever raw material is used, making it more stable. Microbes in the compost pile are breaking down the organic inputs and then converting both the nutrients and carbon into more complex substances that are either useful to them or are products of their own metabolisms. Many of these are comprised of larger, difficult-to-break-down molecules, which we call humus.

Mike is drawn to precision agriculture in order to manage water and nutrients more efficiently. Technology is taking soil health to the next level because it helps farmers understand and manage the different issues in a field. In the past, farmers took ‘bulk’ soil tests, in which one test result would represent the whole field, and would make adjustments to fertilizer levels on a field-by-field basis. But the problem is that a large field may have several different soil types, grades of slope or other concerns. Technology now allows us to make precise soil maps to understand the variability in a field and to make adjustments to fertilizer levels on a metre-by-metre basis. This saves the farmer money but also ensures that soil nutrient levels don’t become so high that they leach into water downstream or harm the microbial communities in the soil.
Mike has worked with Greg Kitching and Trimble’s Soil Information System to create three-dimensional maps of his soil to better understand how to manage fields. First, a small vehicle pulling a ‘sled’ up and down the field collected detailed information related to elevation and the soil’s electrical conductivity. This was used to create a map and to determine where best to probe the soil to assess the field’s variability. The probe measured resistance in the soil to understand compaction and also removed a soil ‘core’ that allowed experts to identify the layers in the soil and how they will impact drainage. Soil samples were also taken to better understand organic matter and fertility levels.

All of this was pulled together to create a map of field variability so that Mike can modify his irrigation and fertilizer plans, in order to be as efficient as possible. The next year, Mike changed the placement and timing of his nitrogen application for sunflowers and was able to reduce fertilizer by 40 percent.

“We say this all the time, but it is true: we can’t manage what we don’t measure,” says Greg, who has been working with Mike for a few years. “The more information we have about what we’re working with, the better decisions we can make.”

“My big wake up call, though, was seeing the amount of compaction we have in the soil,” says Mike. “This affects drainage, soil biology and our yields, so I will need to figure out how to fix that.” Because field flowers involve hand cutting, smaller equipment frequently drives up and down the field. They created ‘drive rows’ which aren’t planted to flowers but are mowed to help control compaction.

Healthy soil needs space for air, water, roots and nutrients to move within it, but heavy equipment or repeated driving can press the pore spaces out of the soil. This reduces water infiltration and drainage, therefore increasing soil erosion from surface water. But compaction also means that roots can’t penetrate the soil to find nutrients, so plants are also stunted and become more prone to diseases.

“I believe we’re called to be stewards of the earth,” says Mike, when asked what motivates him to farm and conserve soil. “And I want to be doing this for a long time, so I don’t want to skimp on investment in the soil. If farmers don’t have good practices, they won’t last.” For Mike, if the soil is healthy, it means the plants will be healthy. “And I see a lot of farmers who are improving the soil, because they have to be competitive and profitable in the long-term,” he says.
Farming in the Greenbelt and in the urban fringe comes with its fair share of challenges for farmers, but also for the soil. The McClures are a long-standing farm family from what is now Brampton. Their old home farm is now under a subdivision.

**Farm History**

Bruce and Joan sold their dairy farm in 1999 to move north into the protection of the Greenbelt where they built a grain storage facility that serves their farming neighbours. This commitment to their community was recognized in 2015 when they were named Peel Region’s Farm Family of the Year. Being so close to the city, the McClures sold their livestock for good and now focus on growing corn, soybeans and wheat.

They farm 2000 acres within a 10-kilometre radius that goes right to the edge of Brampton; 75 percent of the land they farm is rented. Mat McQuillen joined McCluredale Farms originally as their daughter’s boyfriend. He loved being around the farm and
helping out, so Bruce and Joan soon hired him. And when he and Lisa married, the farm partnership also became official. Mat and Lisa now live on the home farm and work alongside Bruce and the family, along with three full-time employees. They hope their two small children will one day take over as the 9th generation to farm in the area.

Farming for Soil Health

To improve their soil and reduce compaction, McCluredale Farms grow cover crops after wheat and are working to minimize tillage. They have a specialized combine harvester that leaves the corn stalk residue finely chopped on the field so that it will break down and be incorporated more quickly into the soil. Because they no longer have access to dairy manure, they have bought compost and applied it to their fields in order to build organic matter levels. They are also improving soil testing to be more efficient with fertilizers.

The McClures farm heavier clay soil that doesn’t have good natural drainage. In other parts of the province, farmers would install subsurface pipes (called ‘tile’) that would allow for better drainage, so the field could be managed properly. But drainage is a major financial investment and, because they farm so close to an ever-expanding city, these investments were never made. Even in the Greenbelt, the majority of their land is rented, and landlords often decline to make such investments.

“I’d say that the lack of drainage is the biggest impediment to soil health in this area,” says Mat. “Because if we drive onto a wet field, we cause compaction and damage to the soil that takes years for it to recover from.” Without adequate drainage, it is more difficult to do no-till planting or to grow cover crops. As a temporary make-shift solution, the McClures dig small trenches in the field to help drain surface water away.
Another way they are dealing with compaction is to use proper tire inflation and reduce unnecessary driving on the field. They use radial tires with the latest technology that allows them to reduce their tire pressure when driving in the field. When tire pressure is reduced, the footprint of the tire on the ground is increased, which in turn decreases the pressures put on the ground per square inch. In Ontario, new tire and air compression technology is allowing farmers to adjust tire pressure in a matter of minutes, so that they can keep the pressure high on the road to drive at the proper speeds and drop the tire pressure as they move into the field in order to be easy on the soil.

Without understanding how much damage wheel traffic can do to the soil, some farmers don’t even pay attention to where they are driving and how often they do it. In 2013, Mat, who by that time was well used to GPS-guidance in farm equipment, decided to control the wheel traffic in the field. He began to modify the equipment to have the same tire axel widths and to create ‘tramlines’ or patterns in the field that could be replicated time and again, so that compaction and crop trampling would be kept to a minimum.

“The technology is there, but it is still difficult to put into practice,” says Mat. Controlling field traffic means not taking the short-cut diagonally through a field, but instead driving to the far end in order to turn around. It also means modifying every piece of equipment in order to fit into a system. Few farmers in Ontario have made it work but, after a few years of trial and error, Mat is growing more confident in his system.

Family is first at McCluredale Farms and so farm succession is part and parcel of sustainability. Without generations of built-up equity, volatile markets and weather can make farming quite precarious. Farming for the next generation means that careful decisions and investments are made into farmland and equipment purchases. And the most basic investment for the next generation is that of the soil.
Compaction Action

Compaction is often created by heavy equipment driving over the soil. Many farmers didn't think twice about it because they thought tillage would solve the problem. However, we now know that compaction and plowing create compaction at the surface as well as deeper in the soil horizons. Compacted soils stop water from infiltrating deeper into the soil, thereby increasing erosion, impeding plant root growth, hindering microbial life, and reducing crop yields. Clearly, farmers are leaving more than just tire tracks behind.

In September 2017, the Innovative Farmers Association of Ontario (IFAO) hosted an expert on compaction, Matthias Stettler, to demonstrate how deep compaction goes in the soil and which types of tires can reduce compaction. Water displacement sensors were placed in the soil at 6, 12 and 20 inches deep, and various types of equipment drove over the sensors in the soil. Farmers saw that large heavy equipment created compaction even as deep as 20 inches, and that even a pick-up truck created significant compaction in the topsoil. One of the worst offenders of the day was an old wooden wagon loaded with hay bales, on small tires. Another of the most telling demonstrations was a manure tanker with twelve tires, each tire carrying an average of 7 tonnes. The tires were inflated to 40 pounds per square inch (psi) and tested over the sensors. Then, the farmer dropped the tires pressure to 10 psi and drove over the sensors a second time with a tremendous reduction of pressure on the soil. The results in the chart below speak for themselves.

In general, the secret is to increase the footprint of the tire in order to distribute the weight over a greater area; wider tires are easier on the soil than skinny ones and the lower the tire pressure, the better. Sidewall technology in tires is allowing tire pressure to go lower than ever, while on-the-go inflation systems allow equipment to inflate tires for travel on the road and decrease pressure within the field.
Bill Allison, Sunrise Acres

Bill Allison grows corn, soybeans and wheat on the urban fringe in Halton Hills and has always been ‘farming on the edge.’ In Halton Region, he farms with two employees and operates about the same number of acres as the McClure family in neighbouring Peel Region. However, unlike McCluredale Farms, Bill doesn’t have children or employees to pass on the farm operation. Nonetheless, soil health is a priority for him because he believes it pays for itself in the short-term, as well as the long-term.

Farm History

Bill’s farm base is in the Greenbelt and is bordered by 18 houses. Growing up farming beside the city in Peel, his family could have moved deeper into a rural area but his father realized there would be an opportunity to rent and to farm pre-development land, as long as they were willing to deal with the issues of farming near urban areas. In the Greenbelt and in the ‘whitebelt’ of Halton Region, Bill farms 31 properties that total about 2,000 acres.

Farming for Soil Health

Bill conserves soil because he believes the payback is not only for the next generation, but for right now as well. He uses conservation tillage, grows wheat and cover crops and applies amendments to the soil to feed the microbiology and increase natural fertility. After he sold his cattle, Bill knew that he needed to invest in some form of manure or compost that would maintain organic matter levels in the soil. He became involved with Halton’s biosolids program and has found tremendous value in it. While Peel region incinerates their sewage biosolids, Halton has been at the forefront of recycling for thirty years.
Adrian Mohammed, the Biosolids Recycling Technician at Halton Region, oversees land application of biosolids in the area. He keeps records and develops plans with the farmers to ensure proper use. Despite the strict quality standards for biosolids, landlords may be uncomfortable with it. Adrian understands public sentiment has been negative towards the product in the past and he works to inform the public about the importance of recycling biosolids. Over the past few decades, regulations have prohibited the dumping of heavy metals into sewer systems and the region's biosolids are now regularly tested and approved to be in compliance with provincial standards. They also follow a strict protocol when it comes to application on farmland, ensuring that applications are done when a field is dry and that setbacks from road ditches, houses and watercourses are kept.

While landlords both inside and outside the Greenbelt are seeing the benefits of biosolid application, another challenge is that owners of pre-development land outside the Greenbelt often prohibit the planting of wheat or hay because these crops attract grassland birds which are species at risk, which could be a problem later when they are ready to develop the land. Farm businesses are exempt from the regulation concerning habitat disturbance in crops, but developers are not. However, wheat and hay crops provide the ideal conditions for land application of biosolids to minimize soil compaction and, without them, this becomes another reason for a missed opportunity.

“We have a waste-free act, and we need the public to really get behind this,” says Adrian. “To be sustainable as a society, we need green bin and yard-waste compost and biosolids to go back to the soil. Until it is applied to the land, it is just waste. But applied to a field, it has many benefits: from mitigating climate change through the reduction of greenhouse gases, to benefiting soil health, increasing yields and improving farm economics.”

“Bill is progressive when it comes to soil health,” says Adrian. “He uses conservation tillage, crop rotation and compost, even on his rented land. Most farmers wouldn’t take the initiative to feed the soil on rented land and that’s where Bill stands out.”

Soil conservation requires an understanding of soil and farming, and a commitment from both the landlord and the farmer-renter.
Bill sees the difference that healthy soil makes and believes that the investment in soil pays off right now. “Yes, it is good for the next generation, but it is also important for my yields and profitability today,” he says. “It really shows up in stress years when there is too little or too much rain.” Still, he admits that it is difficult to justify investments in the soil when he knows the field will be covered with houses in a few years. But all of that changes with respect to land situated within the Greenbelt; Bill knows that this farmland will be preserved thanks to the provincial policy in place.

Nonetheless, the practice of renting farmland is one of the biggest impediments to soil health, both inside and outside the Greenbelt. Soil conservation is a long-term investment and it conflicts with the short time horizons of year-to-year rentals. Soil conservation requires an understanding of soil and farming, and a commitment from both the landlord and the farmer-renter. With the majority of his fields being rented, Bill struggles especially with the lack of adequate field drainage on those properties. This is because he knows very well that proper drainage means less soil compaction from equipment and more opportunities to use no-till planting and cover crops.

For land that Bill owns, he has invested in installing drainage but also in ultra-precise soil testing. A few years ago, Bill had his field tested with the Soil Information System (SIS) described in Chapter 9 and this year again he invested in zone sampling to better understand soil variability and apply fertilizer at a variable rate, only where it is needed.

As Bill explains, in zones that have too much or too little moisture, crops don’t grow. Counterintuitively, these low or no-growth areas don’t need more fertilizer, they often need less. They might not need any fertilizer at all, because the nutrient levels in the soil have built up over time. By not applying fertilizer or biosolids to this area, Bill will save not only on fertilizer costs, but will also benefit the soil, because the over-application of fertilizer can harm micro-organisms or water quality.

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**Farmland Rental Agreements**

Across Ontario, approximately 35 percent of farmland is rented, though this varies across the province. In the Greenbelt, about 43 percent of the land is rented to farmers and this has repercussions for the sustainability of the soil. Researchers from the University of Guelph illustrated that farmers treat rented fields differently from the fields they own and are less likely to invest in planting cover crops or applying amendments. However, they found that after a farmer has rented the field for five years, the difference in farming practices disappears. When there is trust and a longer-term commitment between a farmer and a landlord, there is more opportunity to conserve the land.

Trust and long-term commitments can be built and solidified with a written lease agreement. The overwhelming majority of rental agreements are year by year and based on nothing more than a handshake. In 2016, Farm & Food Care Ontario worked to develop a website resource for both farmers and landlords to understand the importance of building long-term trust and it includes a downloadable farmland lease agreement as well as a check-list to help both parties come to a better understanding of how the soil is being managed. The resources are available at www.farmlandagreements.ca.
Another rather unique farming opportunity exists in Halton to grow hay for the equine industry. Horse farms are common on the hilly terrain of the Niagara Escarpment and hay is a perennial crop that covers the ground for years; it stabilizes, builds and conserves soil.

For Bill, soil health just makes sense from a business perspective. “While we need long term thinking for soil health and food production,” he concludes, “we also need short term flexibility in our year-to-year farming operations. The business is always changing.”
Saunders Family Vineyard

There is an increasing awareness of the role of soil microbiology in agriculture and there are a growing number of biological soil tests that farmers can use, including findings from their own research. The Saunders Family, Niagara-area grape growers, use their own microscope to understand the ratio of bacteria to fungi in their soil. Because grapes are perennial, they thrive in a more fungal-dominated soil, much like a forest.

Farm History

The Saunders Family own and operate an organic vineyard in Beamsville. Warren and his wife, Ivy, purchased the 17-acre property of fruit orchards and a vineyard in 1965, two years after they got married. Warren continued to work at a steel plant in Hamilton, while Ivy left her nursing job to look after the farm. Still active at 97 years old, Warren keeps up with his only farm chore - mowing the lawn on his riding tractor. He is happy that running the farm is now in the hands of the next generation, his son Leslie, daughter Ann-Marie and her husband Peter.

The property is located on the ‘Beamsville Bench’, which is a narrow plateau between the Niagara Escarpment and Lake Ontario. The bench has relatively deep dolomitic limestone clay-loam soils that hold moisture well. The area is slightly warmer due to the lake effect, with a consistent breeze that also moderates temperature. The combination of soil, climate and topography (terroir) on the bench is ideal for fruit trees and vines.
After they purchased the property, the Saunders continued to grow fruit for several years, selling it at local farmers’ markets. Over time, they pulled out the fruit trees and the table grapes, replacing them with wine grapes. Thirty years ago, they anticipated that the future of the industry in Niagara would be in higher quality wines using European grapes. Leslie started the transition by planting a block of Chardonnay. Soon after, the family planted the remaining acreage to more Chardonnay, Cabernet Franc, Merlot, Riesling and Pinot Noir.

In 1984, after more than 40 years of steelwork, Warren retired and was able to devote more time to the farm. It was about two decades later, after Ivy had developed Parkinson’s Disease, that the family decided to become certified organic. Current and long-standing winery clients, Thomas Bachelder Wines and Southbrook Vineyards, make highly acclaimed, single-vineyard labelled bottlings from the Saunders organic grapes.

Farming for Soil Health

Biodynamic viticulture is growing in popularity among grape growers and it was through her participation in the Biodynamic Society that Ann-Marie started to learn about soil microbiology. Biodynamic practices promote the use of livestock and compost to sustain soils. “But this is Niagara and it is difficult to find livestock compost here; then I learned about earthworm castings,” says Ann-Marie. One thing led to another as she began to learn more about vermicomposting and she soon discovered the work of Dr. Elaine Ingham. Dr. Ingham pioneered the ‘soil food web’ approach in which soil microbiology is the driver for soil and plant health. Ann-Marie attended training workshops with Dr. Ingham and now has a better understanding of what to look for, through a microscope, in terms of good compost and healthy soil.

Due to intensive management, most agricultural soil is dominated by bacteria; Ann-Marie’s goal is to bring her soil to a ratio of about 5:1, which means five times as much fungus as bacteria. This is an ideal ratio for vines, shrubs and bushes, according to Dr. Ingham’s teachings. In a forest, fungal networks in soils with ratios of greater than 100:1 connect tree roots underground, allowing the trees to transport food and messages to each other. Mycelia act as ‘roots of the roots’ and connect trees as a community to make them more resilient to stresses from the weather or pests. These mycelia take years to establish and are easily destroyed by tillage or overuse of certain fertilizers. Already having eliminated commercial fertilizer due to organic regulations, the Saunders are now trying to eliminate soil disturbance in order to allow the networks of mycelium to work their magic.

It is common to manage weeds in vineyards through tillage, and vines are also protected through the winter by mounding soil at the base of the vines. Both practices disturb the soil. The Saunders are trying to eliminate the tillage by managing weeds by mowing; they are also eliminating the hilling, hoping that healthier soil will help create the cold-tolerance the vines will need to survive the winter. It may take years of experimenting to get all this right.

The Saunders are experimenting with using compost tea to help protect their vines from diseases such as powdery mildew.
The first priority, however, is to increase the number and diversity of beneficial microbes in the vineyard in order to improve the soil and vine health. The Saunders are experimenting with using compost tea to help protect their vines from diseases such as powdery mildew. Compost tea, like its name may suggest, is a brew of microbes made from compost and it is used as a foliar (leaf) spray or soil inoculant to introduce beneficial microbes to the field.

The Saunders brew 250 gallons of this tea at a time and their mix requires several pounds of vermicompost. Vermicompost is the end-product of a process in which food scraps, manure or leaf waste are fed to composting worms. It is generally considered the best type of compost to use for making this tea. The brewing process consists of mixing the vermicompost with water and microbe food (kelp, oats, humic acid, fish hydrolysate, and a small amount of molasses), then using a powerful pump to agitate and aerate the mixture for about 30 hours. The mixture is then drawn out of the tank and put through a mesh sieve to eliminate larger particles. The finished tea is applied with a sprayer that they drive slowly up and down the rows of vines. This spray coats the entire plant as well as the soil under the vine with beneficial organisms, in the hopes of improving plant immunity and suppressing diseases. The process of brewing and applying the compost tea is quite time consuming, but the Saunders applied the tea to their vines every two weeks during the summer of 2018.

What is Compost Tea?

Compost tea is sort of like a kombucha for the soil. It is a liquid soil-health booster made by extracting the beneficial microbes that live in compost into water, then ‘brewing’ this mixture for up to two days through agitating the liquid with a pump. The purpose of the agitation is to ensure that oxygen levels in the brew stay relatively high because all beneficial soil microbes require good levels of oxygen. Microbe foods, such as fish hydrolysate, kelp, or oats, are added to increase the rate at which the beneficial micro-organisms reproduce. The desired result of the process is a liquid that is rich in beneficial bacteria, fungi, protozoa, and nematodes, which is then applied to the plants or the soil.

Applying compost tea is a relatively new and somewhat controversial practice. Some agricultural professionals think that it has relatively little value, or is at best inconsistent, while others swear by it and use it regularly. Dr. Elaine Ingham, a soil ecologist based in California, is probably the most well-known proponent of using compost tea. She advises its use for several purposes: to suppress disease by coating leaves with beneficial microbes, which crowd out and out-compete disease organisms; to build up the population of beneficial microbes in the soil beneath the plant; and to influence the ratio of fungus to bacteria in the soil. This is accomplished by making the tea more fungal or more bacterial by adding foods during the brewing process that are preferred by the type of organism one wants to select for. Innovative farmers and researchers continue to test the use and effects of compost tea.
The Saunders say that the learning curve on applying these soil-biology enhancing practices is challenging. There are a few other vineyards that are using compost and plant teas but adopting the new processes can be difficult. Also, finding good compost is a challenge and the Saunders are aiming to make their own vermicompost in the future.

While the technology to better understand soil microbiology is available and getting more sophisticated every year, more research on its practical application in agriculture is needed. In the meantime, passionate farmers like the Saunders are leading innovation in these important areas and they are doing it on their own dime.
Owen Goltz, Riverdale Farm and Forestry

Farms come in all shapes and sizes and one of the most unique farms in the Greenbelt has its front lane right on the main street of the town of Inglewood, in Caledon. In fact, five of the farm’s eighty acres are within the town boundaries, including the barn, where the neighbours come to pick up their eggs and produce.

Farm History

Riverdale Farm and Forestry is owned by Owen Goltz and his wife, Susan Graham. Sue is the fifth generation in Inglewood and the couple has developed deep roots in the community. Owen comes from a different background than most farmers. He had a successful career as an arborist and business owner and was drawn to farming only later in his life. This unique background has influenced both his outlook and his approach to farming. He sees the various parts of the farm as one whole, including the forested areas, the fields, the animals, the rocks, rivers and the community in town.
Farming for Soil Health

Owen says that the turning point in his story came when a neighbour found him struggling in the garden pulling thistles one day. Seeing Owen exhausted and frustrated, the neighbour gave him a book that would change the way he worked with the land. The book was Plowman’s Folly, written by Edward H. Faulkner in 1943, in which the author attributed the Dustbowl of the 1930s to the practice of plowing and stimulated a new discussion on alternatives. At the time, the book defied agricultural orthodoxy. Seventy-five years later, it still does.

Owen began looking at how he could work with nature, instead of against it. At the same time, he began to look more closely at the opportunities that surrounded him. For instance, he began to take food scraps and yard waste from his neighbours in Inglewood and turn them into a valuable resource. He now composts these materials for a year in static piles, which he turns with a loader tractor. He then screens the material before applying it to the farm’s fields and gardens. He grows his vegetables in long rows enhanced with this compost and covered with straw mulch to suppress weeds. He keeps permanent grassed strips between the rows to help further suppress weeds, as well as to maintain soil fertility and provide a good working surface.

His vision includes the forested acres as part of the farm. They harvest oyster mushrooms that grow on Manitoba maples, sustainably harvest some trees for firewood, and are developing a strategy to dig and sell burdock root to health food stores. They open their trails and campsites for groups and people to use. They also tap their Manitoba maple trees for sap and boil it down to maple syrup, using wood from the forest. The burning is done in a low oxygen environment (a process called pyrolysis) in order to create biochar.

Owen inoculates this biochar with urine from his barnyard animals, in order to bio-charge it, and he adds this to his compost pile, hayfields and vegetable gardens in the hopes it will increase organic matter levels and provide habitat for beneficial micro-organisms.

Owen’s holistic vision, which includes all parts of the farm working together, extends even to the stones that have been removed from the fields.
Because larger stones can damage equipment, farmers often pick them out of the field and put them in ever-growing piles along the fencerows. But Owen wondered why farmers remove stones only to purchase minerals amendments to apply to the field. He plans to crush some of these stones into a dust and add them back to the soil where they came from.

Some farmers buy microbial inoculants to boost levels in their soil, but Owen believes that the most important microbes are those that are indigenous to the farm itself. He takes soil from several places on the farm and adds these to the compost heap. He then uses the finished compost as an inoculant on his seeds before he plants them. In this way, he believes that every seed that he plants will germinate into a community of beneficial organisms native to the farm and to the area. He also makes sure that the microbes are well fed. He recently purchased a deep root feeder, which is commonly used in arboriculture, to inject amendments such as humic acid, kelp and sea salt directly into the root zone, so that the soil food web around the roots thrives, providing his plants with everything they need to be productive and healthy.

Owen is currently participating in a citizen-science program that involves several farmers in the Erin area. The Soil Health Coalition are measuring carbon levels and water infiltration rates in their soil and sharing results in order to better understand which farming practices improve soil health. Although much discussed, the health of soils is not easy to measure, and it is often difficult to see relative improvements in a short amount of time.
Owen and Susan are building more than soil, they are building community. Neighbours often come by to see the barn and the animals, and many buy their vegetables and eggs from the farm through an online ordering system. The front part of the barn has been converted into a produce pick-up area, but Sue and Owen have also turned it into a creative community space that is used for environmental and healing workshops and community events.

The couple have a unique outlook on farming, and on life. They value community involvement and personal fulfilment on an equal level with profitability. They see themselves as thriving, and not merely surviving. They feel a great sense of privilege to be surrounded by plenty and opportunity. Years after reading Plowman’s Folly, Owen has changed his whole farm and worldview to be one that works with nature; and he doesn’t struggle with thistles anymore.

Respecting and building community to create social equity are the key concepts that drive Owen and Sue, and their vision goes beyond what many ordinarily think of as community. It includes communities of spirit, such as the ones that they have developed on their farm around the environment, healing and social cohesion. In addition, it also includes, vital from a soil-health perspective, the largely invisible communities of the soil food web.
Chris & Craig Mustard, Musthaven Farm

While no-till planting has many benefits for farmers and for the soil, it takes an investment and a leap of faith. Decades after the technology has been available, farmers still debate to till or not to till. But others, like Craig and Chris Mustard, feel that the answer is somewhere in the middle. GPS technology allows farmers to do both! Strip tillage means only disturbing a small strip of soil precisely where the seed will be planted. The rest is left undisturbed in order to preserve the soil’s structure and keep the networks of micro-organisms intact.

Farm History

Twin brothers Craig and Chris Mustard are the 7th generation of their family to operate Musthaven Farm, in the Uxbridge area. They still have the original Crown Deed for the land and they have no intention of quitting; they say it is in their blood.

The two recently took the farm over from their parents, Grant and Rosemary. When Grant was a young boy on this same farm, it was a mix of cows, pigs, chickens, hay and grains, but it became specialized as a dairy farm in 1972 when he came back home after university. Grant had taken a job in Toronto one summer but laughs that he spent most of his time wondering what his family was doing on the farm. So, he came back and farmed all his life.
In 1981, Grant and Rosemary were delighted with twin boys. Craig laughs that he and Chris were enough for his parents. “They asked the doctor what the likelihood was that they would have twins again, and when he told them it was the same likelihood as the first time, they just quit,” he jokes. Craig married Rebecca and Chris married Jill, and they hope their children will want to keep the farm going when they grow up. Over the years, the farm also expanded and evolved. The family was the first in the area to upgrade their parlour to a robotic milking system. They now milk 80 cows with two robots in the barn. They say the cows are calmer now, they prefer being milked on their own schedules and having less contact with people.

Farming for Soil Health

The Mustard family farms north of the Oak Ridges Moraine, on a sandy-loam soil with gravel underneath. The land drains so well that, unlike much of the rest of the Greenbelt area, it doesn’t need any additional sub-surface drainage. They say that the further south they go, the more natural springs they see in the fields, a unique way that the Moraine impacts the area.

However, sandy soils and good natural drainage have a flip side- the increased frequency and severity of drought because sandy soils have lower levels of organic matter. Farmers work to build the organic matter in their soil because it absorbs water like a sponge and keeps soil moist during dry years. Higher levels of soil organic matter also keep the micro-organisms healthy, which in turn keeps the soil structure intact and increases water-holding capacity. This challenge is part and parcel of building soil fertility while preventing soil erosion, especially on slopes, and it is particularly important with sandy soils.

A decade ago, Craig and Chris first saw a local demonstration of strip-till equipment. Impressed, they also found that were eligible for a grant to purchase the implement, so they took the plunge. For them, it meant they could do the tillage in a fraction of the time, without needing a larger tractor to pull the equipment. The first year they faced equipment problems; the sheer bolts didn’t hold up well in their stony soil, which meant that they had to get off the tractor often to make repairs. Like any farmer, however, the solution is often just a bit of tinkering away. They hunkered down in their shop until they fixed the problems. In 2018, they traded in their strip-till unit for a newer one that is better designed for their soil type.

“Another secret to soil health on Musthaven Farm is the cattle manure that the family applies to the soil after wheat or hay is cut.”
So how does strip till work? The equipment makes a 10-inch disturbed strip every 30 inches to prepare for planting soybeans. This saves them time, compared with doing ‘full tillage’ the whole width of the implement. As well, they roll the leftover corn stalks after they plant beans to make sure the stalks have good contact with the soil for the microbiology to break them down over the season. Disturbing only a strip ahead of their soybeans means that the corn residue stays there and, like a layer of armour, protects the soil from the impact of rain and water erosion.

Another secret to soil health on Musthaven Farm is the cattle manure that the family applies to the soil after wheat or hay is cut. Loading manure into the spreader, Grant smiles from the tractor seat and yells over the noise of the engine: “This is the good stuff!” Manure is full of natural fertilizer that helps to grow plants, but it also provides great food for the micro-organisms that keep the soil healthy. However, manure applied in the winter or early spring is susceptible to run-off with melting snow or rain. To counter this risk, the Mustards apply manure in the summer and early fall, ideally onto a living crop. In this way, the manure is utilized immediately and isn’t likely to run off the field. As well, since the fields are dry at that time, the equipment causes less compaction.

Growing hay for the cattle means that soil is covered with perennial grasses for three years in a row at Musthaven Farm, and these living roots keep the soil in place and pump carbon from the atmosphere into the soil. Adding manure to the soil after the hay is cut increases the amount of carbon and organic matter that is put into the soil. Chris and Craig also keep wheat in their crop rotation. “We use the wheat straw for bedding,” they say. “But we also see the benefits to the soil and to the other crops.”

On the sloping areas of the Mustard’s farm, they drive the planter from side to side instead of up and down the hill. This reduces soil erosion because the rows of plants act as tiny berms that intercept water and absorb it, preventing it from picking up speed (and soil) as it goes down the hill.

Chris and Craig hope to pass their family’s long farm legacy on to their children; that means that the farm must remain economically viable and that the soil must be protected. For them, strip-till is one of the many tools they are using to preserve and build on that legacy.
Arnie Lepp, Niagara Orchard & Vineyard Corporation

Arnie Lepp is an orchard grower who is always looking for better ways to do things. Arnie is the owner and President of the Niagara Orchard and Vineyard Corporation (NOVC). He not only manages almost 300 acres of tree fruits and grapes, he also runs a wholesale marketing and distribution company for Niagara-grown fruit. “The focus of this company is on health – healthy soils, healthy trees and vines, healthy people,” says Arnie. He believes that the measure of a healthy soil is a healthy tree and a healthy fruit crop, and he has been producing healthy fruit for decades.

Farm History

Arnie’s family has been farming in the Niagara region since the 1960s. His father had come from Ukraine, where he had been a fruit grower, bought a farm in Ontario and planted fruit trees. When Arnie finished high school, he went to university for a year, but quickly realized that what he really wanted was to be back working in the orchard with his father. “It was a very good decision, in retrospect,” Arnie acknowledges.

Then in 1967 the federal government expropriated their land, as part of the St. Lawrence Seaway initiative. They bought their current farm near Lakeshore Road but continued to grow fruit on the expropriated land by leasing it, along with several other properties, from Transport Canada. Orchards are a long-term investment and farmers aren’t likely to undertake such an investment on rented land. The Lepp family took their chances, however, in hopes that the government wouldn’t build the canal. Their gamble paid off when, in 2017, Arnie was able to buy back their 60 acres of mature orchard from the government.
In 1988 Arnie bought a small local distribution company. It was just one warehouse, about 3,000 square feet. “Vertical integration was the popular concept at that time,” Arnie says. His company gradually bought the smaller distributors in the area to increase efficiency, and they now have about 80,000 square feet of warehouse space. The NOVC packages, markets, and distributes not just their own fruit, but the produce from many of their neighbours. The ‘buy local’ concept has been good for Niagara growers – “Local fruit just tastes better than imported,” says Arnie.

Farming for Soil Health

Growing perennials such as fruit trees and grape vines can be great for the soil, but management still makes a difference for soil quality. Arnie plants cover crops of annual rye grass to build soil organic matter in the sandy soils of his orchards and he tests his soils often to make sure that his trees have what they need to be healthy and productive.

Growing perennials such as fruit trees and grape vines can be great for the soil, but management still makes a difference for soil quality.

“We also do a lot of leaf tissue analysis, followed up by foliar sprays of micronutrients,” he says. His dedication to testing and supplementation has made a big difference, especially in areas where he doesn't irrigate. Arnie feels that this approach to soil and plant health is vital. “If you take vines into the winter in a healthy state and if the plants have everything they need in terms of nutrition, their survival rate is much greater,” he explains.

Arnie is always pursuing new opportunities. He is currently developing a local distillery to make use of unused local tender fruit collected left over in the orchard and from his warehouse that would have otherwise gone to waste. This distillery residues will be applied to the orchards to increase soil health. He used to apply livestock manure to his orchards to build organic matter, but livestock farms in the Niagara Region are now few and far between. The distillery residue will be a new amendment to build organic matter. “The fruit just goes to waste otherwise,” says Arnie. “It can’t be left on the ground in the orchard or vineyard because it harbours pests and disease.” These distillery residues, however, are free of pests and pathogens.
Arnie, like his father, is able to see the golden opportunities hidden in challenges. Whether it is dealing with land expropriation, finding an efficient way to manage pests or finding new ways to build organic matter, Arnie takes on the challenge and turns it into an advantage.

The Niagara Pest Monitoring Club

Arnie Lepp created the Niagara Pest Monitoring Club in the 1990s, after the Ontario Ministry of Agriculture discontinued their integrated pest management (IPM) services to growers. The Club’s membership currently includes 20 growers who are provided with pest scouting and soil testing services. Because of the Club, local growers have more knowledge of local weather and pest conditions and get better recommendations for crop protection and nutrition. This is much more efficient for growers, and better for the environment.

Maria Derkacz is a research scientist with INPRAS Consulting, who specializes in soil science and works with the Club on research projects that will benefit members. The Club has recently received funding from the Canadian Agricultural Partnership (CAP) to research soil-health issues associated with tender fruit growers. She is currently investigating the implications of ‘herbicide strips’ on the soil and on orchards. This refers to an area beneath the rows of trees, a continuous strip that extends three feet to either side of the rows, which is kept bare to prevent weeds from competing with the trees for nutrients and moisture. There is concern that these strips decrease soil microbial activity and increase soil temperature, exacerbating drought and harming tree root-hairs.

The Club’s research will look at alternatives for growers, researching the addition of organic mulch, including compost. To date, Maria has tried mushroom compost, with good results, but she knows that she must be able to document benefits in yield and tree health to get growers to adopt new methods. Research is critical to innovation and to soil health in fruit production.
Overcoming the Challenges to Farming for Soil Health

Of course, most farmers understand how important soil health is, but there are often many obstacles that stand in the way. Soil health requires a long-term investment, often in new equipment and processes, and it can be difficult to make this investment when crop prices fluctuate year-to-year and the cost of farming is so high. There are also social, economic and political issues at play. The farmers that are profiled in this report are exemplary. They are at the leading edge of change and have faced the technical, financial and the social challenges of being innovators.

Socio-economic Issues

To start, farming practices are deeply entrenched in farming culture, tradition and in a network of research and agribusiness companies. For decades, farmers and scientists didn’t understand the impacts of intensive tillage and fertilizer use; now that we have a better understanding, it is difficult to change entrenched practices. When managing debt and risk, it is inevitably easier to opt for the way things have always been done. Moreover, when the consequences of soil degradation and erosion are largely imperceptible, some farmers might not see a reason to change their tried-and-true practices.

The practices that build healthy soil often require a support network of advisors. Counter-intuitively, farming in the urban fringe often means that grain farmers have less access to markets and the support industries like veterinarians, agronomists, equipment dealers and mechanics. As traffic, theft and land prices increase, the grain elevators, retailers and advisors that support agriculture prefer to relocate to more rural areas.
Soil health is an investment, and, like any investment, it requires capital. Rising labour and hydro costs are hard to accommodate when global food prices are unstable. In addition, growing for major grocery chains or grain merchants leaves our local farmers at an economic disadvantage. They don’t have much bargaining power and must take the world price, competing with countries that have more growing seasons and less regulation. Mike Scharringa, of Dutch Mill Gardens, looks to Ontario consumers in hopes that they can create more demand for locally-grown food and flowers. “I think people need to know where things come from but, more importantly, why that matters,” says Mike. “Regulations in Canada are different than those in other countries. We have higher standards here in Ontario and I’m proud to be growing to a high standard.”

The economic barriers to soil health investment are exacerbated near the urban fringe. For some, land prices are so high that it makes extra costs difficult to cash flow. In other cases, farmers believe it is only a matter of time before their farms will be bought for development. The implementation of the Greenbelt has, in many ways, helped these issues by protecting farmland for the future and thereby providing the certainty needed to make long-term investments.

**Farmland Rental**

Building soil requires long-term thinking, but farmland is constantly under threat near urban areas. Bruce McClure’s home farm is now under a Brampton subdivision and, to the east of Toronto, Jennifer Bowman’s childhood farm was paved over for the 407. The Federal government expropriated land for a city and an airport north of Pickering and have rented it to farmers for decades on a year-to-year basis. In Niagara, Arnie Lepp only recently purchased his orchard land from Transport Canada after decades of renting it.

An impediment to soil health both in the Greenbelt and around the province is the lack of long-term rental agreements. Although the Greenbelt Plan has had far-reaching effects on curbing urban sprawl to protect farmland, it hasn’t necessarily meant that farmland is in the hands of farmers. Forty five percent of farmland in the Greenbelt is rented and many of the farmers profiled in this report rent from landlords that own investment properties or retirement estates and may be wary to offer long-term leases to them. The McClure family also rents pre-development land in the ‘whitebelt’ and are grateful when the developer gives them a timeline. If they know they have five years before a field goes for houses, then they can plan accordingly. “Farming pre-development land really helps me appreciate our owned land in the Greenbelt,” says Mat McQuillen. “That’s where we can make improvements for the future.”

“If we don’t know whether we’ll be able to rent a field next year, it is difficult to justify adding compost or planting cover crops on it,” says Bruce McClure. Providing more security than a handshake, long-term leases would allow farmers to invest in the installation of drainage, the planting of cover crops, the purchase of better equipment and in precision soil testing. Also, if more landlords were aware of the benefits of municipal compost and biosolids to the soil and the environment, perhaps they would allow their renters to apply it on their fields.

Drainage is also critical to soil health; farming on wet soil increases compaction which decreases drainage and increases soil erosion. Farmers across Ontario rely on sub-surface drainage to farm properly, so improving drainage is often one of the first steps to reducing erosion and improving soil health. However, these drainage improvements can be quite costly and farmland that is rented often has very poor drainage because, as Mat McQuillen and Bill Allison attested, landlords are not often willing to make the investment.
Crop rotation and soil amendments are also key components to soil health. Farmers who rent attest to the fact that landlords can dictate whether or not they plant hay or wheat. Both of these crops are critical to soil health but may also attract grassland species at risk that could preclude a landlord’s ability to use the property in the future. Furthermore, farmers are nervous over neighbours who may complain about the smell and use of animal manure, compost and biosolids and this creates challenges for farmers and for the soil. Without proper crop rotation and soil amendments, soil health will suffer.

**Research and Knowledge-Networks**

Another key component to soil health is innovation and research. For many farmers, lack of knowledge is the largest barrier to implementing new soil-friendly practices. But, as we can see from the stories in this report, farmers are often doing the research themselves and learning from each other.

There are many great programs in Ontario that support farmer learning. In 2016, the Ecological Farmers Association of Ontario launched a Farmer-Led Research Program that supports farmers to do on-farm trials. Another great example is the Soil Health Coalition, which Owen Goltz and Susan Graham are involved in. This Greenbelt-funded project links a community of farmers in the Erin area to better understand their soil through observation, measurement and shared learning. This citizen-science project is led by Ruth Knight, an agronomist and consultant, who is helping a community of farmers become their own experts.

Twenty-eight sites are involved in this Soil Health Coalition in 2018, which include pasture, market garden and grain fields. Each site has two GPS-referenced sampling areas to compare undisturbed soil from a fencerow with farmed soil. Soil samples are taken to a lab to measure soil carbon and organic matter levels, but farmers also do bulk density tests to determine compaction and soil quality at different depths in the soil. Lastly, they do a water infiltration test, which measures the time it takes for a standardized quantity of water to be absorbed in an area.

The undisturbed areas often have better water infiltration, less compaction and higher levels of carbon in the soil. The challenge, however, is discovering which farming practices can best improve soil to the level of the fencerow. With such a diversity of farm types involved in the project, each will be working with different equipment, barriers and opportunities. Adaptive management is key.

This pilot project is funded by Friends of the Greenbelt Foundation, with additional support from the Town of Erin, Credit Valley Conservation, the Region of Peel, and the involved landowners. It is run in association with Everdale Organic Farm and Environmental Learning Centre and Transition Erin.

Similarly, Arnie Lepp is a key player in the Niagara Pest Monitoring Club, which is a collective of farmers that was founded 20 years ago when the sector lost public research and scouting support in orchards. This year, the Club has been funded by the Canadian Agricultural Partnership (CAP) to monitor soil health within tender fruit orchards and determine how to improve management practices for soil and tree health. Maria Derkacz is a researcher supporting the project and aims to better understand the use of mulching, compost, cover crops and no-till in orchards.
Lastly, the Ontario Soil Network, which Joanne Feddes is a part of, networked 30 innovative farmers from Southwestern Ontario in a leadership challenge to do public speaking and lead farmer discussions primarily about building soil. The program helped Joanne by connecting her with farmers who had experience doing no-till planting and growing cover crops, but it also challenged her to share her own experiences with other farmers in her area.

For many farmers, there are social barriers to trying these new farming practices. Change is difficult, especially doing it alone. Sharing experiences, what worked and what didn't work, is critical to innovation and to building soil health.

**Government Handouts?**

Of course, there are often financial barriers to adopting new practices as well. Ontario Soil & Crop Improvement Association (OSCIA) administers the Environmental Farm Plan and related cost-share programs which many of the farmers in this report have taken advantage of.

Farmers believe that better agricultural policy and less red-tape would make it easier to invest in the soil. Mike Scharringa of Dutch Mill Gardens lists the government regulations, costs and paperwork that he and his staff must complete in order to stay in business. On top of that, his prices are dictated by a global market. Mike believes that if the Ontario government wanted to help conserve soil, they would help make farming viable in Ontario by protecting local markets and prices so that farmers would have the ability to invest in the soil and the long-term survival of the farm. “We don’t want a hand-out,” says Mike. “We don’t want to do all this hard work and then in the end we only survive if the government gives us money.”

Similarly, Eric Bowman of Bowmanview Farms wonders why he is still paying property taxes on the acres of a grassed waterway that he no longer farms but instead provides as a benefit to water quality downstream. He suggests that municipalities could waive tax payments or create incentives for farmland that is set aside for environmental and public good.
Conclusion

Healthier soil means healthier food and healthier people. This report demonstrated that how we farm makes all the difference. The key to sustaining soil health is to mimic nature: leave soil undisturbed, keep it covered with diverse plants, include animals and return organic wastes to the land. This is easier said than done, because farming systems often rely on tillage, bare soil and, increasingly, commercial fertilizer. The farmers in this report, however, are rethinking the way they farm and innovating to conserve the soil.

These are larger issues that farmers find difficulty gaining traction on with governments, especially considering they are such a small portion of the voting population. This is why farmers want to connect with the public and consumer groups to promote soil-friendly policy that will support soil-friendly farming. Through improving government policy and programs and through modifying our food choices, we can have a collective impact to sustain Ontario soils.

The fifteen farmers in this report are great examples of the passion and innovation of farmers in the Greenbelt and across Ontario. They work hard to protect the soil and the environment and are eager to share their stories with the public and politicians. They often regret the lack of communication and trust between farmers and eaters, and hope that the relationship can be improved going forward as we work, as a society, to protect the very foundation of life on earth, the soil.
Appendix 1 – Best Management for Soil Health
Keeping micro-organisms abundant and healthy is the key to keeping soil healthy. Remember the golden rule: do unto others as you would have them do unto you. Just like us, the living things in the soil need food, water, air, shelter and communities. Mimicking nature is best and, in nature, soil is always covered with a diversity of plants, and grazed by wild animals, with virtually no disturbance.

In practical terms, we can build healthy soil by:

1. Growing a cover crop in between the main 'commericial' crops;
2. Adding organic amendments such as animal manures or composted food waste;
3. Reducing fertilizer and chemical inputs;
4. Reducing tillage & minimizing soil compaction;
5. Diversifying the food that we grow and
6. Protecting soil from wind and water through windbreaks, berms, swales or grassed waterways.

Below are examples of specific practices that have been used in Ontario or elsewhere. Some of these practices cost farmers money to implement because they require purchasing new equipment, taking land out of production or risking yield losses. Apart from the practical and economic barriers, there are also social barriers to gaining knowledge that goes against the orthodoxy of traditional farming practices.

**Cover Crops**

On many farms in Ontario, crops are harvested by October. The land is then tilled or left uncovered for the winter and the spring, until another crop is planted in May. The winter melt and the spring rains are when soil is at the greatest risk to water erosion, so planting something that will grow in the non-growing season helps to keep the soil in place. These ‘cover’ crops may be harvested or grazed in the fall or spring, but the most important thing is that they are alive and growing, harnessing the energy of the sun and the carbon in the atmosphere and turning them into food for the microbes below.

There are many different options farmers can use for cover crops, depending on what they need: some plants are killed by a frost but others will survive to ‘over-winter;’ some can increase nitrogen levels in the soil (legumes); some are good at controlling weeds or diseases (brassicas); some are good at breaking up compaction (radish, rye) and improving soil structure. Below are various options for planting and terminating cover crops.
1. Planting after harvest: Wheat is harvested in July or August and creates a great opportunity to plant a cover crop afterwards, whether it be a single species or multiple. Planting a variety of different species in the cover crop mix can ensure a more even cover. In some wet areas, one species may do well, but in the dry areas another one will thrive. Or ‘bio-strips’ can be planted: these are alternate rows of soil-holding (fibrous root, overwintering) crops and tillage-type (tap root, winter-killed) cover crops. In the spring, this results in clean but undisturbed strips to plant into. Other cover crops are grown specifically to control diseases in the soil, as ‘bio-fumigants’ (see Chapter 4).

2. Frost-seeding: A cold-tolerant seed can be broadcast on a field while there is still frost or snow on the ground and this reduces soil compaction and saves time planting a cover crop later. Red clover is often broadcast in February or March onto fields of winter wheat. It germinates and may lie dormant until the wheat is harvested, after which it covers the field. Red clover also produces nitrogen for the subsequent crop, which in most cases is corn (5, 10).

3. Inter-seeding: This is most often done in corn but has also been attempted in soybeans. A cover crop is planted in between the rows of the commercial crop after it has started growing. This can be done by blowing on or drilling in the seeds with an implement, or from a helicopter or plane. Research demonstrates there is a critical ‘weed-free’ period that a crop needs to establish without plant competition for maximum yield, but before and after that, cover crops do not negatively affect yields. After harvest, these cover crops begin to grow in earnest. Because they feed the soil biology, keeping it abundant and active, they also facilitate the break-down of the corn residue for the next season (3).

4. Terminating after planting: Most farmers that do use cover crops terminate them with tillage in the fall or in the spring. But some of the most innovative farmers are actually planting ‘no-till’ into a living cover crop and then terminating the crop chemically afterwards. This allows for the maximum amount of growth in the cover crop and, therefore, the maximum amount of energy and carbon stored in the soil. This has been done successfully into cereal rye and is also used with bio-strip cover crops (3, 5).

5. Roller crimping: A few farmers are taking ‘planting green’ to the next level and terminating the cover crop after planting without chemicals. Instead, they are rolling over the cover crop with a crimping implement that will kill it and leave it lying as a thick mulch. This mulch suppresses weeds as well as protecting the soil surface and feeding the microbes (2).

6. Not killing the cover crop: So far, only a few minor attempts have been made to not terminate the cover crop, but to mow it low throughout the season between the rows. In the future, this may be done in conjunction with strip tillage.
Including Animals & Amendments

Over the last decades, the food industry has become specialized and consolidated. Farms have as well, with many specializing in either dairy, beef, pork or chickens, etc. and keeping their animals in larger and larger barns. Many others sold their livestock altogether and focused on grains, fruits or vegetables. This poses another problem to farms because animals are a necessary part of soil sustainability. The “preliminary” work of the micro-organisms within the digestive system of animals (especially ruminants) are beneficial to soil micro-organisms. When applied properly, manure, including human biosolids, is one of the missing links to soil health and critical for the recycling of nutrients and sustainability of agriculture.

1. Composting manure: some farmers are composting their manure before they apply it to their fields, through windrows or in an active compost pack within the barn. This process decreases the volume, pathogens and odour, and stabilizes the nitrogen and other nutrients, so that it will be better for the environment when applied (2, 5, 9).

2. Composted food waste: other farmers truck in compost purchased from municipalities, or they compost organic wastes on their own farms using vermicomposting, anaerobic digestion or other innovative technologies. In general, composted materials release their nutrients more slowly than raw manure or anaerobic digestate. Some farmers prefer the quick availability of nutrients in un-composted material while others prefer the slow, longer-term release afforded by compost (10).

3. Compost tea: A small number of farmers are working on ‘brewing’ a liquid form of high-quality compost. This process creates an ‘inoculant’ of micro-organisms that can be applied to the soil or as a foliar (leaf) spray (12).

4. Biosolids: Though historically controversial, improved regulation and technology has reduced pathogens and heavy metals in municipal sewage treatment facilities. This allows valuable macro and micro nutrients to be returned to the soil. Biosolids are applied in strict adherence to application guidelines developed by the government (11).

5. Manure application: Farmers with liquid manure (hog and dairy) are developing ways to apply manure directly into the soil through injection, to avoid subsequent runoff. Others are timing the manure application such that it is spread onto a growing cover crop, so that these plants can take up the bio-available nutrients immediately. Some farmers are using a variable rate of manure application, depending on the soil-test nutrient levels, and others are using a drag line to apply manure (as opposed to a heavy tanker) to minimize the weight of the equipment and subsequent soil compaction.

6. Managed rotation grazing: The best way to add animal manure is to bring them to the field to graze the hay or cover crop. A few farmers are taking grazing to the next level by limiting the area that an animal can graze so that they unselectively consume the plants and trample manure into the soil. The cattle are shifted to another section of the field daily or even hourly, allowing the grass a month or two to recover before being grazed again. This mimics the way that herds of animals used to graze, when predators kept them in bunches and moving often (2, 5).
Reducing Fertilizer

With the increasing demand for food over the last decades, most farmers have come to rely on commercial fertilizers. While nutrients are obviously beneficial to making plants grow, too many readily available nutrients can have negative effects on soil health. Excess nitrogen can reduce organic matter and too much phosphorus can limit the growth of fungal networks. But perhaps even more harmful is the recent finding that with too much fertilizer, the plants stop feeding the microbes. As discussed in Chapter 1, plants pump carbon out through their roots to feed microbes in exchange for the nutrients that the microbes provide them. However, if the plant roots have too much nutrient easily available to them, these trading processes may be slowed. This can impact the plant later in its growing cycle, when nutrient levels in the soil have dropped and most of the plant’s microbial allies have dispersed due to a lack of any reward for their efforts. This process can also negatively impact disease suppression, as some of these microbes are important partners with plants in fighting off various types of pathogenic organisms. In order to reduce fertilizers, avoid hurting the soil food web, yet maintain adequate plant nutrition, farmers must better understand their soil nutrient levels and the best way to do this is through regular soil testing.

1. Haney/Solvita soil testing: New soil tests are using a biological extraction process instead of a chemical one and this test has potential to help scientists better understand the soil.

2. Precision soil mapping: Technology has been developed that can map various soil types, textures and soil nutrient levels across the field (grid sampling, Soil Optix, Smart Firmer etc.). This may change how farmers choose to manage certain sections of the fields, which may be quite different from each other (9, 11).

3. Variable rate technology: Agronomists can program a fertilizer or manure prescription for a farmer based on these soil tests and the planter or fertilizer spreader will adjust rates on the go. Farmers can also increase and decrease the seeding rate and plant populations in certain areas as needed. Using variable rate allows farmers to use less fertilizer, which improves both soil health and water quality (7).

4. Organic production: Under organic certification regulations, commercial fertilizers are not permitted in fields. And while organic systems may rely on more tillage, they must take care to amend their soils with manure and cover crops in order to maintain crop productivity (2, 12, 13).

Reducing Tillage & Compaction

Tillage is tradition. Plowing is perhaps one of the most iconic symbols of farming and it does have many immediate benefits. It kills the weeds, warms up the soil, provides a ‘seed bed’ for planting, and releases a flush of plant-available nutrients. Over time, however, it also destroys the soil structure and creates erosion. Healthy soil is like a sponge: its structure creates lots of spaces, which can hold water and air. Tillage, whether plowing, discing or cultivating, destroys this structure of the soil. Furthermore, driving on the soil with heavy equipment or when the soil is wet also crushes the soil structure. Minimizing tillage and the use of heavy equipment increases soil health and reduces the problem of compaction.
1. No-till: with the development of new herbicides and hydraulic down-pressure systems on planters, farmers have been able to plant directly into un-tilled soil. The first few years transitioning to no-till may mean reduced yields. This is because the burst of fertility created by tillage is lost, while the microorganisms have not yet had time to re-establish their high fertility communities (3).

2. Strip-till: No-till has a down side -- it is problematic to add fertilizer or manure to a field when it can’t be tilled to mix it in. By disturbing only a 10-inch strip in the soil to add manure or fertilizer, the rest of the field is left undisturbed (14).

3. Perennial crops: fruit trees, asparagus, and rhubarb are all examples of perennial crops that can grown for years without tillage. Hay and pasture are also perennial crops, along with miscanthus, which is grown for bedding or biomass (2, 8, 12, 13, 15).

4. Reducing tire pressure and equipment weight: One of the simplest ways to decrease the impact of equipment on the soil is to reduce the weight of the equipment or to increase the footprint of the tire, through using wider tires or reducing their pressure. There are systems that can decrease tire pressure on tractors and equipment as they enter the field and increase them back to road-pressure as they leave (10).

5. Controlled traffic: The best thing for the soil is to not have heavy equipment on it at all. Some farmers modify their equipment to a standardized axel width and only drive on established ‘tracks’ in the field or use laneways to limit the amount of times they have to drive on the field (10).

6. Robots: Though they might be a few years from commercialization, there are several companies designing ultra-small robots that will do virtually no heavy damage to the field and do precision planting and crop management. These robots could be a game-changer for soil health.

**Increasing Diversity**

Diversity begets diversity: as it goes above the ground, so it goes below. Diverse systems are more resilient, and to increase the diversity of micro-organisms in the soil, farmers are increasing the diversity of plants and inputs above the soil.

1. Extended crop rotations: The more crops a farmer grows in succession, the better. Diversity improves soil health. All the grain farmers in this report grow wheat, and other farmers are experimenting with crops that are new to Ontario and will help to improve the diversity in their rotation.

2. Multi-species cover crops: Some farmers are planting 3 species and up to 25 species of cover crops in the same field to increase diversity and resiliency (3).

3. Relay cropping: Farmers are innovating to grow two crops together in the same field in alternating rows to increase diversity. Wheat is planted in the fall and a row of soybeans is planted in between in the spring. Once the wheat is harvested around July, the beans will grow larger and will be harvested around October (7).

4. Intercropping: A number of different crops can be planted and harvested together, and separated later, in order to increase diversity.
Reducing Erosion

There are some places that just should not be used for farming. Sometimes the soil is too thin, or the area may be very wet or have too steep a slope. Over time, soil can move from the top of the hill to the bottom, or water movement can form deep gullies in a field. In other cases, wind can dry out the soil and blow it away. Therefore, farmers must sometimes change the landscape in order to keep soil in place. ‘Green infrastructure’ protects soil from erosion and can be used in conjunction with the in-field management that benefit the soil microbiology.

1. Grassed waterway: This is a permanently grassed area along a water run or low draw in a field to protect the soil from being washed away with rain or melt water (2, 6).

2. Controlled drainage: Using control gates on subsurface drainage pipes can allow the water table to be raised and lowered depending on the time of year, providing more water for plants during the growing season.

3. Water and Sediment Control Basin (WASCoB): Often designed on the edge of the field, this berm holds the water back for a period and allows suspended soil to precipitate out and back onto the field (6).

4. Contour swales: Carving small swales into a slope on contour will intercept and redirect water, distributing it more evenly across the field or property (8).

5. Landscape restoration: Some farmers have had success in taking topsoil deposits from the ‘valleys’ and moving it up to cover the top of eroded knolls.

6. Windbreaks: Strips of trees along the edge of a field help to slow down the wind from drying out soil and crops or blowing soil away (9).