INVESTING IN SOILS FOR A SUSTAINABLE FUTURE

THE ENVIRONMENTAL COMMISSIONER'S
SOIL-CARBON ROUNDTABLE REPORT

Environmental
Commissioner
of Ontario

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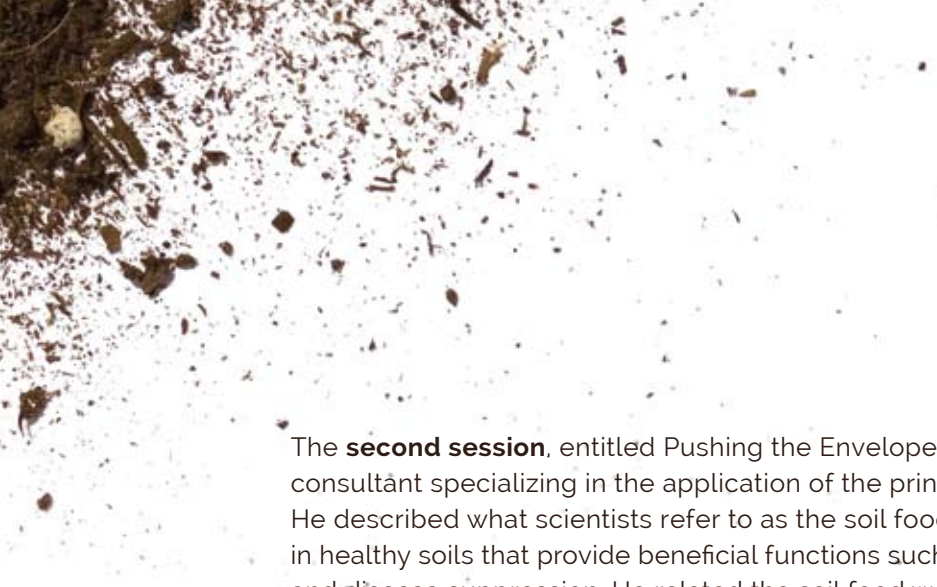
EXECUTIVE SUMMARY

SEVERAL IMPORTANT THEMES, RELATED TO SOIL HEALTH, WATER POLLUTION, resource depletion, and climate change impacts, are converging around the issue of soil carbon. Accordingly, the Environmental Commissioner of Ontario, Mr. Gord Miller, brought together a range of stakeholders and experts for a one-day roundtable, with the goal of providing a better understanding of the opportunities and challenges associated with this unique convergence. The roundtable was organized into five sessions.

In the **first session**, Dr. Paul Voroney of the University of Guelph emphasized the vital importance of soil carbon to climate change, soil health, and agricultural productivity. He discussed the basic science of soil-carbon sequestration and presented the results of some research that he has led at the university over the past three decades. He stated that plant residues and other organic inputs are the only way to reliably increase soil-carbon levels and that conservation tillage, while important for other agronomic reasons, does not sequester carbon.

The second presentation, by Anne Verhallen and Adam Hayes of the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), focused on the Ontario situation. They reminded participants that the issue of soil carbon has been around for a very long time and that OMAFRA has been working with Agriculture and Agri-Food Canada (AAFC) for many years to provide soil conservation programs for Ontario farmers. They discussed the Environmental Farm Plan, which includes a cost-sharing component for farmers implementing best management practices (BMPs). They discussed other types of support, including research and education, and said that they are starting to see some of this work pay off in terms of an increased focus on soil health among some farmers.

During the subsequent discussions, participants agreed that soil carbon is an important issue and that a number of BMPs, such as cover crops and crop rotations, are already known to increase carbon levels in soils as well as provide agronomic benefits to farmers. Some other practices were also noted, including the application of municipal compost, precision fertilizer application, and purpose-grown energy crops. Barriers to implementing these BMPs included the difficulty and costs of measuring soil carbon and the costs of inputs such as municipal compost.



The **second session**, entitled Pushing the Envelope, began with Doug Weatherbee, a consultant specializing in the application of the principles of soil ecology to agriculture. He described what scientists refer to as the soil food web—the populations of microbes in healthy soils that provide beneficial functions such as nutrient cycling, soil aggregation, and disease suppression. He related the soil food web to the process of carbon sequestration. He explained that the prevailing concept that large, hard-to-degrade, organic molecules such as lignin were mainly responsible for long-term sequestration, has recently been overturned. The most recent scientific thinking is that carbon sequestration is an ecosystem property and that factors such as soil type, temperature, and the characteristics of the soil food web are all instrumental in sequestering carbon in soils.

The next speaker, Dr. Johannes Lehmann of Cornell University, seconded the point about carbon sequestration being an ecosystem property. He then went on to define biochar and assess the opportunities and challenges associated with it as an agent for increasing carbon levels in soils and for promoting plant growth and soil health. He emphasized the need for a life-cycle approach, stating that in some cases biochar might result in more carbon in the atmosphere, rather than less. He described a project in New York State, where biochar-amended soils produced no yield increase and no increase in nitrogen uptake by plants, but significantly reduced nutrient leaching and increased nitrogen retention in the plants' root zones.

Participants in the subsequent discussions had varied opinions as to the value of the approaches described. With respect to the soil food web concept, some expressed great interest, others expressed a cautious interest, and still others felt that it was either not yet well enough understood, or that it was of marginal practical application. Concerns expressed included the complexity of the subject matter and the lack of practical tools. Reaction to the biochar information was also mixed, with some expressing strong interest in its potential to sequester carbon, reduce fertilizer requirements, and minimize water pollution. Many others, however, felt that biochar was more suited for use with degraded soils and had little potential benefit for Ontario farmers, especially given its price of several hundred dollars per tonne.

The **third session** focused on the concept of financing positive change, or how to best provide incentives for farmers to adopt the BMPs. The first speaker, Ian Campbell of AAFC, described some of the options used in other jurisdictions, such as carbon taxes, cap and trade mechanisms, offsets, and the international Clean Development Mechanism (CDM). He discussed carbon prices, which range from about $7/tonne in New Zealand to about $30/tonne in British Columbia, stating that eventually these prices would need to be substantially higher. He focused on the concept of bundling vs. stacking in paying for ecological services; the former refers to incorporating multiple benefits (e.g., water quality, soil conservation, etc.) into one payment; the latter involves separate payments

for each benefit. His overall message was that there are opportunities to link soil carbon to multiple ecological services, particularly for local initiatives, but that it is important to be very careful to avoid unintended consequences.

The second speaker, Karen Haugen-Kozyra of the Prasino Group, discussed the issues involved with assigning economic value to carbon. She began by reviewing the work of the International Panel of Climate Change (IPCC) on agriculture and carbon. She stated that the fourth IPCC report had found that the contribution of soil carbon to climate change mitigation could be quite significant, particularly within developing countries. She also reviewed current carbon-pricing systems, focusing in particular on North America. She talked about the challenges in measurement, verifiability, permanence, and leakage. She then discussed the use of life cycle analyses and, using milk as an example, described how several large companies are trying to reduce their carbon footprint, 70 per cent of which comes from the milk production stages. She stated that for Ontario, the best opportunities for sequestering carbon probably lie with the application of organic inputs such as municipal compost and biochar.

The participants in the subsequent discussions agreed that financial mechanisms of some sort are required; however, there was not agreement on which mechanisms are best. Many supported the concept of bundling, as described by Mr. Campbell; however, the question of financing the bundled payments remained open. Suggestions included a carbon tax, general tax revenues, a consumer tax, and the private sector (via cap and trade mechanisms). Participants suggested several existing programs for use as models, including the Alternative Land Use Services (ALUS) Program and the Environmental Farm Plan. Several economic barriers were identified, including the lack of Ontario-specific protocols, the opportunity cost for farmers, and the high cost of both measurement and program implementation.

The **fourth session** was a farmer's perspective on the roundtable issues, provided by Don McCabe, the Vice-President of the Ontario Federation of Agriculture (OFA). He stated that this issue was too important to ignore: policies are being set at the international level that will have impacts at the farm level. Soil carbon has been ignored for too long. He stressed the need for government research and stated that the length of research programs should not be measured by the political calendar. Good government policy should incent good action and investment by everyone. He declared that Canadian agriculture is 10 per cent of the problem and 20 per cent of the solution and disagreed with the University of Guelph's findings that no-till does not sequester carbon. He stated that the world is moving towards carbon-accounting in agriculture and Ontario can either choose to lead or choose to delay another ten years. Farmers can sequester carbon for the world but they need the right policy mechanisms to succeed.

The **fifth and final session** consisted of a plenary session where participants had an opportunity to make final comments. The following is a sample of some of the views expressed.

- The most important thing is to develop accurate and consistent quantification methods.
- A multi-stakeholder working group is needed to oversee the development of the methodologies.
- The governments of Canada and Ontario need to be challenged directly on the issue of soil and food security.
- An *energy return on energy invested* perspective needs to be adopted.
- The focus should be on proven BMPs.
- Soil should be elevated to its proper place in society (one of its basic foundations).
- It should be a high priority to move Ontario well above the current level of 10 per cent food self-sufficiency.

For ECO Comment, see Page 47.

Note: this document has been prepared to provide a general summary of the presentations and discussions shared at the Roundtable. The ideas and positions set out in the paper do not necessarily represent the views of the ECO.

INTRODUCTION

The Environmental Commissioner of Ontario (ECO) convened a roundtable on Soil Carbon on March 30, 2012, to initiate a province-wide multi-stakeholder discussion on soil carbon in Ontario. The ECO invited eight speakers to present on various topics of interest related to soil carbon, and facilitated plenary and small group discussions following each session.

This document provides a detailed summary of each presentation, the plenaries, and the small group discussions. In addition, video recordings of all speakers' presentations, as well as their slides, are available on the ECO website at www.eco.on.ca.

Commissioner's Opening Remarks

The Environmental Commissioner of Ontario, Gord Miller, began the roundtable with an observation that every once in a while an issue comes along that represents a unique convergence of several important and relevant themes; soil carbon represents just such a convergence.

Soil carbon is not only relevant to climate change, with potential for both mitigation and adaptation, but also to:

- soil health and the long-term sustainability of agriculture;
- water pollution from agricultural run-off;
- resource depletion, as in the concepts of peak phosphorus and peak oil; and,
- biodiversity—the vital question of how we maintain ecological complexity.

To speak to these important converging themes, the ECO brought together a range of stakeholders and experts with unique knowledge and experience to discuss how aspects of soil management, climate, environment, and economics might be integrated around this concept. He hoped the roundtable would provide participants with a better understanding of the issues as well as some idea of the opportunities that might come out of this unique convergence.

SESSION ONE

Soil Carbon and the Ontario Experience

Dr. Paul Voroney | UNIVERSITY OF GUELPH

Dr. Paul Voroney provided a basic primer on the opportunities and challenges associated with soil carbon, from a scientific perspective.

Dr. Voroney stated that soil carbon sequestration is a timely issue, given climate change concerns created by rising concentrations of carbon (C) in the atmosphere and the fact that agricultural practices over the centuries have reduced carbon in soils by between 30 and 60 per cent, usually around 50 per cent. Soil organic matter (SOM) constitutes a very significant C pool; it is almost twice as large as the atmospheric C pool, and three times the size of the biotic C pool. A rough figure for the amount of C in the top 30 centimeters (cm) of a hectare of soil is about 100,000 kilograms (kg) (100 tonnes).

BIO

Dr. Voroney is a researcher at the University of Guelph in the field of soil biology and biochemistry, biogeochemical cycling of soil carbon, nitrogen, and the effects of soil management and cropping practices on the nature and dynamics of soil organic matter constituents. His work also includes the practical aspects of soil management, organic waste management, and organic agriculture. Dr. Voroney has been working in the field, studying soil carbon and related matters, for more than 35 years.

Therefore an opportunity exists to sequester some of the excess atmospheric C in the soil, thereby mitigating climate change. However, he emphasized that climate-change considerations are not the only reason to sequester carbon in soils; SOM is the key to all soil properties, whether they are physical, chemical, or biological. In terms of nutrients, when SOM is at 4 per cent, it provides 10,000 kg of nitrogen (N), 2,000 kg of phosphorus (P), and 2,000 kg of sulfur (S) in the top 30 cm of topsoil. Of these amounts, generally between two and three per cent is mineralized (made available to plants) each year.

In terms of soil chemistry, Dr. Voroney differentiated between humic and non-humic materials and discussed the problems involved in separating these substances for study purposes. Humic substances are fairly stable and can have an apparent life of thousands of years, while non-humic substances are more readily degradable. He then discussed the various models that have been developed to try to understand and predict soil C levels. He noted that the various "pools" (i.e., classes or types) defined within these models—active, slow, passive, etc.—are conceptual rather than measureable, thus making verification difficult. Other measurement difficulties include the slow rate of change in soil-C levels, as well as the geographical variations in SOM (sometimes ten-fold differences within small regions). Overall, an annual input of plant residues totaling about 8 per cent of the C already in a soil is required to maintain SOM levels. Dr. Voroney pointed to the results of some long-term studies in Ontario that show no fundamental increase in soil C due to conservation tillage. He stated that, in his opinion, it could be considered definitive that C levels are a function of organic-matter inputs and that tillage methods are not a factor.

Dr. Voroney objected strongly to the idea that organic residuals are not useful if left in the field and that, therefore, someone should "make an automobile bumper out of them". To the contrary, he argued that crop residuals are absolutely essential to the vast network of soil microbial life, which itself is fundamental to soil health. In particular, microbes play an essential role in soil aggregation (i.e., the clumping of soil particles into aggregates of various sizes), which improves soil structure and is one of the basic requirements of a healthy soil.

He finished by summarizing his main points.

1. Conservation tillage does a number of good things, but C sequestration is not one of them.
2. Plant residues are extremely important and need to be returned to the soil, both to feed the microbes, which are vitally important to soil health, and to sequester carbon.
3. The only way to increase soil C is to increase organic inputs.

QUESTIONS FROM THE AUDIENCE

and Dr. Voroney's answers

1. *What about crop rotations? Do they affect microbial diversity and do they help sequester C?*
   They do increase C sequestration over time and they probably increase microbial diversity, although he has not studied that subject directly.

2. *What about plant-root exudates?*
   He has found from carbon-tracing studies that exudates are mostly consumed by microbes over the growing season and therefore do not persist in soil in large quantities.

3. *Are you saying that the loss of C in the western prairies was due to decreased organic inputs and not to tillage?*
   Yes. Grassland ecosystems are more productive than farming, so more carbon is sequestered via plant residues, both below and above ground.

4. *Does the addition of compost add more C than the use of fertilizer?*
   Fertilizer increases productivity and therefore increases crop residues, thus building SOM. When plant material is composted, half of the C and some of the nitrogen are lost in the composting process. His guess is that as a result the sequestration produced by compost would be equal to that of fertilizer, at best.

Adam Hayes & Anne Verhallen | OMAFRA

Adam Hayes and Anne Verhallen, from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), provided the Ontario update on soil-carbon related policies and programs.

Adam Hayes observed that the soil carbon issue has been around for a long time. He quoted a 1949 statement about how row cropping was destroying the soil structure, referred to the 1978 PLUARG (Pollution from Land Use Activities Research group) report, and cited Herb Sparrow's 1984 report, Soil at Risk, which documented the problems faced by Canada's soils.

BIO

Adam Hayes and Anne Verhallen are both Soil Management Specialists, the former in the Field Crops unit and the latter in the Horticulture Technology unit, of the Agriculture Development Branch, Economic Development Division of OMAFRA. Their recent work includes a project to adapt the Cornell Soil Health Assessment for use in Ontario, as well as a number of research and demonstration projects on soil management practices.

Mr. Hayes noted that OMAFRA has been working with Agriculture and Agri-Food Canada (AAFC) for years to provide programs on soil conservation for Ontario farmers, which includes information on best management practices (BMPs) such as: reduced tillage; no-till; cover crops; residue incorporation; tree planting; and erosion control structures. As an example of the results of these programs, he cited Essex County, which used to have some of the worst soil problems in Ontario due to its early settlement and conversion to row crops. Over the past 20 years the county has shown significant improvement, with more even crops and less standing water visible in the fields.

Anne Verhallen asked whether participants were aware of the Environmental Farm Plan (EFP), which is OMAFRA's flagship project on soil health and conservation. Most participants were aware of the EFP. This program is based on risk assessment and includes a soil management worksheet, which requires farmers to evaluate their soil-management practices, including estimates of their soils' organic-matter levels. The EFP program includes a cost-sharing component for farmers to implement new BMPs, including conservation tillage, manure storage, cover crops and tree planting.

Ms. Verhallen indicated that within OMAFRA, a soil team has been in place for about 20 years. The soil team provides support both to other OMAFRA employees and to growers, generally in the form of technical advice via on-going extension services and educational activities. OMAFRA also works closely with researchers at the University of Guelph and with federal government researchers, and has established a network with researchers in

other states and provinces where growing conditions and major crops are similar. In 2003 and 2006, OMAFRA ran a series of workshops across the province for growers that included information on soil quality, soil health, and the best ways to build SOM.

Ms. Verhallen noted that a major part of what OMAFRA does is translating researchers' work into valuable tools for farmers. It has offered a series of guides on BMPs for the past 20 years. OMAFRA offers growers a soil fertility handbook and an agronomy guide for field crops that has been revamped in recent years to include a section on soil health. Education and building capacity in agriculture have both been important areas of focus for the ministry. Work in these areas has included field days, during which topics such as tillage, compost, compaction prevention, and soil life have been featured, and conferences, such as the Southwest Ag Conference, which has in recent years included speakers such as Fred Magdoff and Ray Archuleta, strong proponents of soil health.

Adam Hayes finished the presentation by stating that OMAFRA also provides support for research, some of it dedicated to carbon sequestration and building SOM. Other relevant ministry activities include: looking at the potential for offset trading and the necessary protocols; monitoring developments in these areas; doing some modeling on how to protect crops from the impacts of climate change; hiring an agroforestry specialist; and researching the potential of organic soil amendments such as digestate from anaerobic digesters and municipal compost.

The ministry is working on a project evaluating the applicability of the Cornell Soil Health Assessment to Ontario, with the hope that this test will become a valuable means for educating growers. The OMAFRA approach has been and will continue to be multi-pronged, including working with producers, researchers, and governments. The ministry's message is that it wants to help growers understand soil, soil health, and the role soil organic matter plays in protecting the environment and enhancing productivity. The ministry is starting to see this work pay off at meetings, where more people are talking about soil health, SOM, and soil degradation and its impacts.

QUESTIONS FROM THE AUDIENCE
and the speakers' answers

1. *Relative to its potential, how much work in soil organic matter and related issues has OMAFRA done already?*
   There is still a lot to be done; they have just scratched the surface. It is important to realize that with adult education, progress is slow. Nevertheless, the ministry has seen an increase in interest by growers in the past few years. Once one farmer puts in cover crops, for instance, neighbours are curious and the word spreads.

2. *How close are we to a formula for emission trading purposes?*
   Not that close. Protocols are being developed elsewhere, but for them to be workable for Ontario farmers, they need to be confirmed scientifically within the province. So, there is still a lot of work to do.

3. *How much work is OMAFRA doing to target urban centres?*
   OMAFRA's mandate is primarily to work with commercial growers. However, the ministry has some involvement with the local food movement. From a practical perspective, it is easier to work with the large commercial growers because there are fewer of them and the time spent providing information and support goes a lot further.

Participants' Comments & Discussion on Session One

In general, the roundtable participants seemed to agree on a number of basic points.

- Soil carbon is an important issue.
- A number of BMPs are already known to increase soil carbon, so at least some of the tools are readily available.
- These BMPs have other agronomic and environmental benefits besides increasing soil carbon, and so are valuable in their own right.
- These BMPs include (but are not limited to):
  - » cover cropping;
  - » returning crop residues to soil;
  - » manure applications; and
  - » crop rotations.

DEFINITIONS

Conservation tillage

"A broad range of soil tillage systems that leave residue cover on the soil surface, substantially reducing the effects of soil erosion from wind and water. …Some specific types of conservation tillage are Minimum Tillage, Zone Tillage, No-till, Ridge-till, Mulch-till, Reduced-till, Strip Tillage and Crop Residue Management." Source: United States Department of Agriculture (USDA), 2007.

No-Till agriculture

"No till essentially involves eliminating all tillage operations, and placing seed, fertilizer or manure with minimal soil disturbance. Other terms used to describe the practice are zero tillage and low disturbance direct seeding."
Source: Agriculture and Agri-Food Canada (AAFC).

Cover crop

A crop grown for the protection and enrichment of the soil.
Source: Oxford Dictionary.

Crop rotation

The planned sequence of crops growing in the same field year after year.
Source: Agriculture and Agri-Food Canada (AAFC).

There was no general agreement as to whether or not no-till farming sequesters carbon in soil; however, it was generally agreed that conservation-tillage practices are beneficial, both agronomically and environmentally, and should be encouraged along with the other BMPs.

In addition, participants identified a number of other practices potentially useful for sequestering carbon. These include:

- the application of municipally derived compost to fields;
- intercropping (growing two or more crops on the same field) and agroforestry (growing crops between rows or clumps of trees);
- increasing yield via precision fertilizer applications and other advanced nutrient-management methods, so that more carbon is photosynthesized by crops; and
- purpose-grown energy crops (perennial grasses such as switch grass can sequester carbon over time via their root systems and associations with soil microbes).

A number of participants mentioned that many of the tools required to promote these methods were already in place and saw OMAFRA's Environmental Farm Plan (EFP) as a potentially valuable vehicle in this regard. Education was also stressed; some participants felt that getting the information out to farmers was key to greater adoption of these BMPs.

With respect to the barriers to adopting these (and other) BMPs, many participants mentioned the difficulties involved for farmers in measuring soil carbon. It was suggested that this service needs to be provided by government. Economic factors were also mentioned, including: the costs of testing; the issue of land value when considering agroforestry (which uses more land per unit production); the dependence of no-till methods on herbicides and the growing herbicide-resistance problem; the high cost of municipal compost (when transportation is included); the costs of on-farm composting (including both capital and on-going operating costs); and the competing demand for crop residues for energy production.

Participants also pointed out that no-till can increase nutrient run off, because the fertilizer is often not incorporated into the soil. Finally, there was general concern regarding the issue of permanence, with the concern expressed that farmers who adopt a BMP in return for carbon credits might find themselves required to maintain that practice indefinitely.

ECO OBSERVATIONS ON SESSION ONE

The participants generated a good overall picture of the potential for soil-carbon sequestration and the barriers to realizing that potential. In particular, they expressed concern with the problems and costs associated with measurement and administration. At the same time, there was a general agreement that the practices that sequester carbon also provide a number of other benefits. For the farmer, these include soil improvement and conservation, yield enhancement, and reduced input costs. For the natural environment, the benefits include improved water quality, flood protection, and preservation of biodiversity. The question becomes one of how best to define these benefits and to develop the most appropriate incentives to maximize their uptake in agriculture.

SESSION TWO

Pushing the Envelope

Emerging approaches and practices are also extremely important; they can offer important new perspectives, opportunities, and challenges to soil carbon sequestration. The Pushing the Envelope session focused on an emerging discipline (the application of the science of soil ecology to agriculture) and an ancient but recently re-discovered practice (the intentional addition of charred organic material to soils).

Doug Weatherbee | SOILDOCTOR.ORG

Doug Weatherbee presented on the role of soil biology in agricultural production and carbon sequestration.

Doug Weatherbee began by describing an agricultural project in Mexico with which he had been involved in 2009. Crops were failing all over Mexico due to a drought—five weeks with no rain at all. However, by treating one corn crop with microbiological methods, Mr. Weatherbee claimed he was able to overcome the drought and produce good yields. The impact of the methods (the application of liquid compost,

BIO

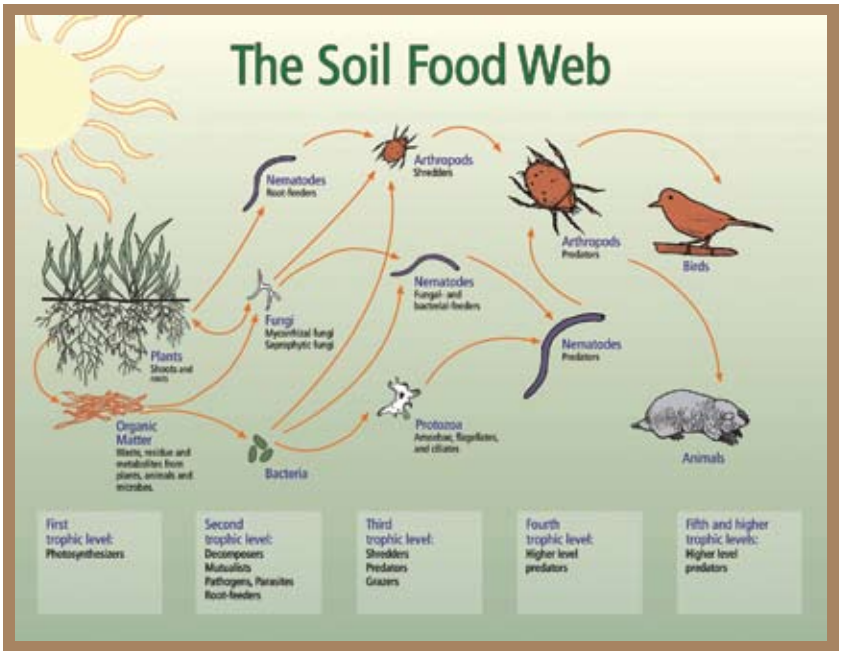
Doug Weatherbee is a Certified Soil Foodweb Advisor and owner of SoilDoctor.org, an agricultural training and consulting company that specializes in applying the science of soil ecology to soil management and food production. He is based in Mexico but works with farmers all over North America, including Alberta. His focus is on how to reduce chemical inputs and irrigation through an emphasis on good soil microbiology.

primarily) could be seen in the root systems, which were much larger in treated plants than in untreated ones. This fact introduced the concept of the soil food web, both as a biological term referring to the web of creatures that live in the soil, and to an approach to agriculture that is based on promoting the health of these organisms.

Mr. Weatherbee described the soil food web components and their inter-relationships. Most plants send up to 50 per cent of the product of their photosynthesis (various carbohydrates, amino acids, and other carbon-based substances) down into their roots, where it either contributes to root growth or is released as an exudate into the rhizosphere (the soil immediately adjacent to the roots). These exudates feed a variety of microbial members of the soil food web, consisting primarily of species of bacteria and fungi, which are attracted to the rhizosphere by the availability of these exudates. In return, the microbes make various types of nutrients available to the plants. This is the basic nutrient cycling system that underlies all natural plant growth.

He provided detail on how this nutrient cycling occurs. In the case of bacteria, which are extremely numerous and varied in a healthy soil, predation by larger microbes, such as protozoa and nematodes, releases their embodied nutrients in the root zone in plant-available form. In the case of fungi, there are two basic types, each with associated mechanisms by which nutrient exchange occurs. Decomposer fungi are attracted to the root zone by the organic materials sloughed off by the roots, which they consume. As in the case of bacteria, when these fungi are themselves consumed by predators, their nutrients are also released in plant-available form. Mycorrhizal fungi, however, are symbiotic with plants in a different manner. They actually attach themselves to plant roots and exchange water and nutrients (particularly phosphorus) with the plants in a kind of trading system, receiving photosynthetic products in return. All of these activities are extremely important for carbon sequestration because, as studies have shown, much of the carbon sequestered in soils for long periods is of microbial origin.

Mr. Weatherbee also described how the principles of ecology are used in the type of agricultural management system he practices. He described the process of ecological succession, by which disturbed habitats (such as an abandoned farmer's field) move through a series of plant communities on their way back to a stable or climax ecosystem, which could be a grassland or a forest, depending on annual moisture, soil type, and other factors. Typically, this process starts with fast-growing weedy species, moves into grasses, then to shrubs and fast-growing trees, and finally becomes a mature forest. As this happens, usually over decades or more, a succession also occurs below ground, with the microbial communities moving from bacterial dominated (disturbed habitat), to a more even mixture of bacteria and fungi (grassland) to fungal dominated (woodlands). This is applied to agriculture by first determining the general ratio of fungus to bacteria in the field in question, then comparing that to the ideal ratio required for the specific



Source: Soil and Water Conservation Society (SWCS). 2000. Soil Biology Primer. Rev. ed. Ankeny, IA: Soil and Water Conservation Society.

crop to be grown. If the ratio is wrong for the crop, the grower will try to change it by adding bacteria or fungal composts or compost extracts.

In general, agricultural soils tend to be bacteria dominated. This is because bacteria are hardier than fungi and are able to survive and thrive in conditions such as those found in modern farming. Practices such as conventional moldboard tillage, the use of fungicides to control disease, reductions in organic matter applications (e.g., plant residues, manure, compost), and the application of synthetic fertilizer all tend to favour bacteria over fungi, with the result that the latter are lacking in many farm soils. Because fungi are instrumental in the process of soil aggregation, fungal-deficient soils are prone to compaction. Mr. Weatherbee indicated that he was not calling for farmers to abandon synthetic fertilizers and fungicides, but that these facts should be kept in mind.

With respect to carbon sequestration, Mr. Weatherbee revealed that he had recently undergone a transition in his thinking on this subject, so that he now has more questions than ever. He related an example of some cotton farm trials in Australia. Until 2002, the land received five tonnes of cotton trash per acre each year. In 2003 they replaced this with 300 pounds of compost per acre. By 2006, both the fungal biomass and the levels of carbon in the soil had risen, the level of nitrogen fertilizer required each season had dropped, and the yield had remained the same. Something was clearly happening in the soil, but what?

The old view is that carbon sequestration is a chemical process and that the inputs had to include some big, tough carbon-based molecules (e.g., lignin) in order for long-term carbon to be sequestered. The newer view, however, (one that he said is supported by

the latest research), is that carbon sequestration is not just a chemical process, but a process dependent on soil type, moisture, and the microbial communities at work in that particular soil—in other words, it is an ecosystem property. He predicted that over the next few years, genome-based testing will fill in the gaps in this view, making it more practical for the purposes of predicting carbon sequestration.

Finally, he added a practical note about how no-till should always be practiced in combination with good cover crops. He discussed the work of the U.S. National Sustainable Agriculture Information Service in the area of cover crops, which is showing that good species diversification is needed, with up to 14 species, rather than 2 or 3. He also talked briefly about his work with an Alberta farmer, who is producing 20,000 tonnes of compost per year for application to his land, has eliminated the need for phosphorus fertilizer, and is looking forward to reducing his input costs considerably with no sacrifice in yield.

QUESTIONS FROM THE AUDIENCE

and Mr. Weatherbee's answers

1. *Is it the biological activity that sequesters carbon, rather than the original inputs?*
   It is everything—we used to think it was just chemical, but it is much more complicated than that, and that is what we need to understand and embrace.

2. *In your first example (Mexico), was compost used? What other biological methods were employed?*
   They used reduced tillage, liquid composts, and fungal foods.

3. *How do you make fungal compost?*
   The starter materials need to hedge more towards a carbon-rich mix, but you still have to have enough nitrogen to get the temperature up. There are some good recipes available.

4. *Which is more effective, adding the soil microbes directly (as in compost tea), or creating the conditions that will encourage and support them?*
   He didn't know. More research is needed. The new methods based on genome technologies should give us more precise answers in the future.

Dr. Johannes Lehmann | CORNELL UNIVERSITY

Dr. Johannes Lehmann presented on the subject of biochar use for soil-carbon sequestration.

BIO

Dr. Johannes Lehmann is associate professor of soil biogeochemistry and soil fertility management at Cornell University. He is also Chair of the International Biochar Initiative. He is generally considered the leading academic voice internationally on the potential of biochar both as a way to mitigate climate change and as a way to enhance soil fertility.

Dr. Lehmann indicated that his presentation would focus on both soil carbon sequestration and soil health. These topics are currently being advanced in many directions, and the science of soil microbes is one of the most promising. He referred to the work discussed by Mr. Weatherbee (soil carbon sequestration as an ecosystem property) and stated that he had been involved in publishing a summary paper and giving presentations on that subject. In fact, he stated that he has been giving presentations of late entitled "The Quiet Death of Soil Humus", because he feels that there is no identifiable substance in soil that can be called "soil humus." The development of new technologies, however, should allow us to better understand what is going on in soils.

He talked about biochar specifically, referring first to the "terra preta" soils of South America. These soils were treated with charred materials many hundreds to several thousands of years ago and still retain very high nutrient content and cation exchange capacity (a general measure of soil fertility), which can be traced to the char component. He noted that the agronomic value as such is not a new insight, that agricultural texts from earlier times in North America state that charcoal is as valuable a soil amendment as compost. He stated that char is found in all soils, worldwide, at percentages (of total soil carbon) ranging from the single digits to over 80 per cent. High-char soils are often associated with high fertility and the ability to hang on to cations, thus reducing nutrient leaching and losses. For instance, with regard to the highly fertile mid-western soils of North America, there has lately been a shift in thinking. The new understanding is that the high fertility of these soils is the result of a fairly high char component. He stated unequivocally that it has been proven that char has a positive effect on soil health.

Dr. Lehmann explained that the opportunities presented by biochar may be approached from several different directions: waste management, climate change mitigation, energy production, and soil fertility. The question is whether all potential benefits need to be present for a biochar project to be commercially, environmentally, and socially viable. In partial answer to this, he proposed that the stability of biochar in soil is a key for all of those interests. If biochar is not more stable than the precursor material from which it is made, then its value drops considerably.

The carbon cycle is the basis for the soil's potential to mitigate climate change. If the release of carbon from the soil as carbon dioxide (CO_2) can be slowed down, the relative proportion of carbon in the soil and in the atmosphere can be changed. With biochar, this depends on its stability in soil. Some biochar lasts less than 100 years, some lasts more than 1,000 years. The determining factor has yet to be identified, but at least one scientist has shown that the molar oxygen-to-carbon ratio is important.

Stability is necessary, but not sufficient. He then described the results of various life-cycle analyses, which showed that in some circumstances, the production and use of biochar in soils actually increased CO_2 in the atmosphere, rather than the other way around. Factors to consider include the energy expended in growing and transporting feedstock, use of the fuel (if any) produced by the pyrolysis process that made the biochar, as well as indirect land-use changes. Overall, care needs to be taken in making decisions about biochar, to ensure that the benefits are not overshadowed by the environmental costs, similar to any soil amendment such as composts or fertilizers.

When using biochar in soil, a careful balance is required. Too much water or too much nitrogen can kill a plant, even though they are both necessary for its survival. Different soil types will respond differently, as will soils in different climates; in addition, different biochars can have very different characteristics, depending on the original feedstock and the temperature at which the pyrolysis is carried out.

While this complexity might deter a potential user (or producer), the fact that this much variability exists could turn out to be a good thing. The possibility is certainly there to produce "designer" biochars for different soils and climates. He gave the example of a study in New York State, where over four years biochar-amended soils produced no yield increase and no increase in nitrogen uptake by crops, but significantly reduced nutrient leaching and increased nitrogen retention in the crops' root zones. Therefore, Dr. Lehmann said, biochar could have potential in temperate zones for reducing fertilizer requirements as well as minimizing nutrient losses from farms.

Dr. Lehmann also discussed the impact of biochar on microbial biomass. He said that nine times out of ten, microbial biomass was increased when biochar is added to soils. This biomass increase usually includes mycorrhizal fungi as well as certain growth-promoting bacteria. This is a frontier that needs to be explored.

Biochar is available on Amazon.com; however, since biochar properties vary considerably, chances are that the purchaser will not really know what they are getting. To try to deal with these issues, Dr. Lehmann and others created the not-for-profit organization known as the International Biochar Initiative (IBI). This organization has developed *The IBI Standardized Product Definition and Product Testing Guidelines for Biochar That Is Used in Soils* (the *IBI Biochar Standards*) and is now working on biochar production sustainability guidelines.

QUESTIONS FROM THE AUDIENCE

and Dr. Lehmann's answers

1. *What is biochar and what does it cost?*
   Biochar is one of the products that result from the heating of organic materials, such as wood or other biomass, in the absence of oxygen. The most well-known example is the charcoal used in barbecues. The cost of biochar in the developed world is similar to the cost of charcoal, which is used to produce energy. It is in the range of several hundred dollars per tonne.

2. *Where does the char in prairie soils come from?*
   It is thought to have come largely from fires set by human beings, probably aboriginals, in times prior to European settlement.

3. *Biochar is by definition a product of incomplete combustion. Complete combustion eliminates all contaminants, such as polycyclic aromatic hydrocarbons and dioxins, but incomplete combustion produces these types of contaminants. Does biochar contain these substances?*
   A recent paper shows that such contaminants are very low in biochar. This is probably because they are typically formed at temperatures of 1000°C or higher, and the pyrolysis process used most often to produce biochar runs at about 600°C or less, so the contaminants are never formed.

4. *What is the potential for biochar in terms of climate-change mitigation? We have heard some very optimistic estimates.*
   If you just use technical potential, you can estimate global sequestration values equal to the burning of fossil fuels. However, after you take environmental and social factors into account, an estimate of about one gigatonne per year emerges. Even this is extremely optimistic, however, and we should not use biochar as a substitute for reducing our emissions of greenhouse gases, which should be our highest priority.

   Overall, Dr. Lehmann would suggest that biochar is among the top 20 approaches to withdrawing CO_2 from the atmosphere, which is significant. Again, however, this should be considered as secondary to the primary goal of reducing emissions.

Participants' Comments & Discussion on Session Two

Applying Soil Ecology to Agriculture and Soil-Carbon Sequestration
The participants' reaction to Mr. Weatherbee's presentation was more mixed than was the case for the earlier presentations. Some expressed great interest in the potential of this approach, while others expressed a cautious interest, and still others felt that it was either not yet well enough researched and developed, or that it was of marginal application to agriculture.

Those who viewed this approach positively stated that it is time to look at the soil as an ecosystem and that the science of soil ecology can help farmers understand why certain BMPs work and how to optimize them. They felt this approach could potentially reduce farm input requirements, saving money for farmers while generating significant environmental benefits.

Others were mainly positive but a bit more cautious, stating that: these methods have not yet been tried at any significant scale in the province; the financial viability of this approach is still uncertain; it is extremely complex and at this point lacks simple, practical methods; and more research is needed into how the science can be applied practically and cost effectively.

A final group felt that it has marginal applicability at best and that the focus should be on conventional BMPs, which, if applied appropriately, would ensure that the soil biology looks after itself. Another related perspective was that diversity is the best indicator of soil health and that biodiversity can be assessed by observations made above ground, without having to test the soil.

In terms of barriers, those who supported the approach felt that it needs more testing in Canada and specifically in Ontario, in order to develop a good set of tools and also to determine how well this approach works in conjunction with conventional inputs, such

as chemical fertilizers and pesticides. They expressed the need for DNA-based tools for rapidly and accurately assessing both general soil health and also specific soil-microbe populations and functions. Supporters also suggested that farmers wishing to adopt this approach should receive both technical and financial support during the transition years.

Biochar and Soil-Carbon Sequestration

Biochar as a soil amendment also received a mixed review from the participants, but with perhaps even less support expressed and more questions raised than was the case with the soil ecology approach.

Some of the positive opinions expressed included:

- biochar, unlike compost, fertilizer, etc., only has to be applied once;
- the scientific work to date shows that biochar supports and enhances beneficial soil microbe populations; and
- biochar could possibly be mixed with fertilizer prior to application to improve nutrient retention in soils.

Many questions were raised, including the following:

- How does it compare in effectiveness with other soil amendments, such as compost?
- While it appears to help marginal soils, what benefits does it bring to good soils?
- It is expensive, so how viable is it economically?
- Ontario generally does not have acidic soils, so does biochar make sense from a pH perspective?

Those who were not supportive (the majority, it seemed), stated that:

- biochar is too expensive;
- it has too many unknowns associated with it;
- there are currently no producers in Ontario, resulting in high transportation costs for users;
- it might be useful for city gardens, but not for commercial agriculture;
- our soils are fertile and don't need it; and
- higher-value end uses already exist for charcoal (energy production, water treatment).

Many barriers were identified for biochar. The most obvious one is its cost, which is set by its value as an energy source. This is several hundred dollars per tonne, according to Dr. Lehmann. The second major barrier has to do with its questionable value to Ontario's relatively fertile soils. Alternatively, those with some interest in the potential of biochar saw a lack of research and demonstration projects in Ontario as a major barrier. At least one

participant pointed out that the cost of biochar need not be so high; the development of mobile pyrolysis units that could travel from farm-to-farm producing biochar from excess crop residues or woodlot thinnings might reduce the cost considerably.

ECO OBSERVATIONS ON SESSION TWO

The roundtable's "pushing the envelope" presentations appear to have done just that, creating discussions that were more varied and less consensual than the earlier discussions on the more conventional BMPs associated with soil carbon sequestration. Many good points, both pro and con, were raised regarding both subjects.

From the ECO's perspective, the topics of these two presentations are linked in a fundamental way. As discussed in our 2009/2010 Annual Report, the ECO believes that biochar has great potential value to both enhance soil health and minimize nutrient run-off. The ECO believes that biochar's physical structure (i.e., the very large surface area and multitudinous refuge sites for microbes) and its chemical characteristics (i.e., its propensity for attracting and holding on to cations) make it a natural enhancer of the beneficial soil food web, as described by Mr. Weatherbee.

The ECO recognizes that this science is relatively new and (perhaps most importantly) goes well beyond the boundaries of the more conventional agricultural sciences. The ECO hopes that this unfamiliarity does not present an insurmountable obstacle to the further exploration and possible development of both approaches in the future.

SESSION THREE

Financing Positive Change

This session focused on financial mechanisms available to encourage the adoption in Ontario of BMPs that increase soil-carbon levels. The two speakers were asked to provide: 1) an overview of the types of mechanism used in other jurisdictions; and 2) a more detailed presentation on carbon credits and offsets as they apply (or could apply) to soil carbon.

Ian Campbell | AGRICULTURE AND AGRI-FOOD CANADA

Mr. Campbell began by providing a summary of the types of economic tools available to date for mitigating climate change. The first set of tools consisted of greenhouse gas (GHG) offset systems. Examples included:

- the now-defunct Chicago Climate Exchange—a voluntary system where large emitters were able to offset their emissions by buying credits from farmers;
- regulatory cap-and-trade systems, such as those now operational in Alberta, Australia, and the European Union;
- a carbon tax combined with offsets, as in

BIO

Ian Campbell is the Associate Director of the Environmental Policy Division, Strategic Policy Branch, Agriculture and Agri-Food Canada. Since 1986, except for a year spent with Ducks Unlimited Canada, he has worked for the federal government. His experience includes market research, environmental assessments and farm income stabilization programs. He is currently responsible for developing policy on ecological goods and services and other environmental issues.

British Columbia (B.C.), where emitters can forego the tax if they purchase offsets from agricultural producers (soil carbon is not an option, however);
- the international Clean Development Mechanism (CDM); and
- the pending Western Climate Initiative, which will (at this point) consist only of California and Quebec, and will put a price on carbon of about $10/tonne.

With regard to other types of incentives, Mr. Campbell mentioned:

- those that are used to promote best management practices;
- education and awareness programs;
- on-going research into better technologies and practices for mitigating climate change;
- regulation; and
- bundling climate-change benefits with other ecosystem services (discussed later).

He outlined the federal position, pointing out that the federal Department of the Environment is responsible for the Government of Canada's international negotiations on these issues, as well as for monitoring, reporting, and policy development. With regard to the latter, Canada is committed to co-ordinating with the U.S. approach, mainly because of the integrated North American economy. Although a framework for a draft GHG offset system at the national level was developed by 2009, it has never been enacted.

Mr. Campbell also spoke about the relatively new Australian Carbon Farming Initiative, legislated in August 2011. This program caps carbon emissions by industry, exempts agriculture from the caps, and then allows farmers to sell carbon credits resulting from the adoption of accredited BMPs. Soil carbon and biochar are included in these potential BMPs, but to date the protocols have not been developed. He stated that this is a young program but one that interested parties should monitor.

His next topic was price levels, expressed as Canadian dollars per tonne of CO_2 equivalent. These currently range from $7 per tonne in New Zealand to $30 per tonne in B.C. (the B.C. carbon tax). He expressed the view (commonly held by climate-change professionals) that carbon prices would have to go much higher to effect significant change. However, going higher than $30 per tonne at this point is problematic, as it would put Ontario companies at a competitive disadvantage. He could not venture an opinion as to when that situation would be remedied.

He touched briefly on the complications inherent in offset systems in agriculture, noting that Ms. Haugen-Kozyra would address these in more detail. He did mention the issues of:

- permanence in soil sinks (changing the practice could reverse the sequestration);
- baseline definition (identifying the business-as-usual case for various actions);

- the small scale involved, creating a need for aggregators (small increases in carbon per hectare might not be big enough to warrant a transaction);
- high relative transaction costs (the difficulty in measuring and monitoring change might create costs higher than the value of the benefits); and
- the problem of additionality between systems, programs and benefits (i.e., the question of whether a new action adds benefit or just replaces the benefit provided by whatever it replaces).

He mentioned the Environmental Farm Plan program as a potential lever for affecting GHG emissions from farms. Other such levers include:

- straight subsidies for BMPs;
- feed-in tariffs, such as the ones Ontario offers to those who install wind turbines or anaerobic digestors;
- creating cross compliance with income stabilization programs, so that farmers would be required to adopt certain practices in order to qualify for benefits; and
- policies promoting other ecological services, such as water quality.

Regarding the last option in the above list, he pointed out that most BMPs have multiple benefits, affecting soil health and fertility, wildlife habitat and biodiversity, flood protection, etc., and could be promoted regardless of the difficulties involved in measuring actual changes in soil-carbon levels.

The challenge with using a wider definition of benefits, however, lies in the difficulties involved in linking the various beneficiaries with the farmer. Some of the benefits are international (e.g., GHG reduction) and some are local (e.g., water quality). There is a well-recognized gap between the costs to the farmer and the benefits, which may be widely distributed throughout society. Finding fair and efficient ways to bridge that gap is a real challenge. As an example, he referred to some work he had done with Ducks Unlimited, trying to measure the benefits of putting riparian zones into agricultural regions. They found that the net economic benefits were positive ($198/hectare/year), but that they were widely dispersed and only about one-quarter of the benefits were due to GHG reductions.

Mr. Campbell also introduced the concepts of bundled vs. stacked benefits. In the case of bundling, all of the ecological benefits (e.g., carbon sequestration, water quality, soil conservation) of an activity (e.g., use of cover crops) are incorporated into one payment, which becomes a tradable environmental instrument. In the case of stacked, unbundled benefits, each environmental benefit associated with an activity (e.g., the soil conservation benefit of no-till) has its own separate payment (again, potentially a tradable environmental commodity). Finally, in the case where there is neither stacking

nor bundling, an environmental benefit (such as water quality) is used as the basis for a payment for an action (such as the installation of buffer strips) and the other benefits go unrewarded. He said that there is considerable research going on in this area, with the goal of developing a viable methodology.

In the meantime, there are many things of this nature going on in Canada. A few of the examples he presented are as follows:

- BMP insurance in Prince Edward Island;
- water-quality (phosphorus) trading in Ontario;
- tax credits and auctions in the western provinces; and
- carbon offset trading in Alberta.

He provided some input from work that Environment Canada and the provinces have been involved with (an Ecological Goods and Services Working Group) over the past few years. The main points were:

- local initiatives work better;
- accountability requires that the results be measureable and efficient;
- market-based instruments should be used whenever possible; and
- partnerships with non-agricultural stakeholders are important.

Some of the pitfalls identified were:

- a single, national program would not adequately reflect local conditions and is not recommended;
- annual payments are only effective under very particular conditions (e.g., as a transition measure to a fiscally sustainable tool);
- regulations are also only recommended in special circumstances (i.e., may be required as a backdrop for market instruments to function); and last, but not least,
- ecological goods and services programs that indirectly substitute for farm income support are inefficient for both income and environmental purposes.

Mr. Campbell presented a few examples of unintended consequences arising from these types of subsidies. For instance, he showed an aerial photograph of the border between Alberta and Montana. The difference in land use was very noticeable, with the Canadian side showing a high percentage of wooded land and the American side showing almost 100 per cent farmland. This, he said, was the result of income support for annual crops. The message: be careful with payment programs, as they can have an effect beyond what was intended. Finally, he summarized his presentation by saying that: soil-carbon systems are being developed; there is potential to link them to other ecological services; local initiatives seem the most promising; and "be very careful."

QUESTIONS FROM THE AUDIENCE
and Mr. Campbell's answers

1. *You pointed out that the federal government is not planning to put a price on carbon, or to put an emissions trading system in place, but some recent regulations passed for emissions from coal-fired power generation facilities included a "social cost" of $25. So it is being done to some degree. Now farmers want certainty, and a price on carbon seems to be the only way to make that happen.*
   There is a lot of potential, particularly in southern Ontario, for using these types of methods (e.g., adding a "social cost") to encourage the displacement of coal with something like biomass, using simply the regulatory regime they already have in place. This needs to be looked at.

Karen Haugen-Kozyra | THE PRASINO GROUP

Ms. Haugen-Kozyra began by stating that, while the early portion of the roundtable had focused on carbon sequestration at a very granular scale and on a scientific level, she would be talking about carbon sequestration at a much larger scale, for the purposes of assigning economic value.

The goal is to find simplicity at the far side of complexity. In this regard, her presentation would focus on what is working in Alberta, and her efforts to evaluate whether the science is robust enough to bring the BMPs into an accounting framework that works for carbon markets. She emphasized that BMPs require years of research before they can be pulled into a system that measures the net changes in the three greenhouse gases for which agriculture has a share of

BIO

Karen Haugen-Kozyra holds an MSc in Soil Microbiology and Biochemistry from the University of Alberta and is an active member of the Alberta Institute of Agrologists. She served for 13 years in various sustainable policy, planning and technical positions within the Alberta Department of Agriculture and Rural Development and was seconded to Climate Change Central in early 2007. There, she implemented the necessary market processes, infrastructure and tools needed to get the carbon offset market off the ground. Currently, Karen is a consultant working with various groups in the U.S. and Canada active in the carbon offset space.

responsibility—CO_2, methane (CH_4) and nitrous oxide (N_2O). She noted that we are on the verge of developing those BMPs and making them practical for farmers, but there still is a ways to go.

She talked about some work done by the Intergovernmental Panel on Climate Change (IPCC), in its 4th Assessment Report. The IPCC comprises panels of scientists from all over the world that review the latest research on GHG emissions in several disciplines and across all economic sectors. The panel comes up with a synthesis on procedures and guidance for how to quantify GHG emissions. There are several panels for agriculture, one each for methane (enteric/manure-based), CO_2, carbon sequestration, and N_2O from soils. Each country takes this guidance, customizes it based on local research, and uses it to develop an emissions inventory. This inventory is done at a very large scale and is spatially and temporally averaged and conservative. This has been an invaluable resource.

In terms of carbon sequestration, the IPCC's third assessment report on agriculture had produced a very broad and theoretical quantification of the potential for soil carbon sequestration. The fourth report looked at the constraints and what a price on carbon might do as a stimulus for soil-carbon sequestration in agriculture and forestry. The report found that the contribution of soil carbon to climate change mitigation could be quite significant, particularly in developing countries; this was an opportunity largely missed within the Kyoto Protocol.

Why is carbon pricing so important? The policy tools that are available to government to reduce emissions are: regulation; performance standards; and carbon pricing. Of the three, carbon pricing seems to make the most sense, because it gives industry the greatest freedom to innovate and develop the most efficient ways to reduce emissions and, most importantly, it provides a constant incentive to do so. In most of Canada, carbon is emitted free to the atmosphere; in Alberta, however, about 100 companies are capped at a certain intensity level and each year they must reduce that by 12 per cent. So they are beginning to factor this into their business decisions. That is why chartered accountants in both Canada and the U.S. now have carbon accounting principles and direction in their procedures. Industries outside of the cap system, such as agriculture, have an opportunity to capture revenues by adopting practices that reduce emissions or capture carbon.

Ms. Haugen-Kozyra then gave a brief overview of carbon-pricing systems around the world and in North America. Unfortunately, there are no pan-American or pan-Canadian comprehensive systems; rather, we have a patchwork of partly or yet-to-be implemented systems across the continent. The Western Climate Initiative's (WCI's) carbon-trading system, scheduled for implementation in January 2013, had previously included several U.S. states and Canadian provinces, but has now been reduced to California and Quebec.

In Alberta, the current system allows capped businesses several compliance options: pay $15/tonne into a technology fund, which is used for carbon-related research; spend money on internal carbon-efficiency improvements; or invest in carbon offsets. The offset share of the compliance money has doubled, from 18 per cent to 36 per cent, between 2007 and 2010. This is because the market is becoming more comfortable with purchasing offsets, a significant portion of which come from no-till agriculture. No-till, as a carbon-sequestering practice, works well in the prairies' semi-arid soils because N_2O emissions are lower, but does not appear to offer the same opportunity for the moister soils in Ontario, due to higher N_2O emissions from soils.

She discussed a study that she did on the subject of biological-based reductions in carbon. Biological methods have not proceeded as far as some other methods due to certain constraints, including:

- generic estimates of potential have so far been done only at a large scale;
- additionality has to be considered, which requires business as usual (BAU) definitions; *[Note: This criteria addresses the question of whether the project would have happened regardless of the revenue from carbon credits. Only carbon credits from projects that are additional to the BAU scenario are typically considered eligible.]*
- permanence is a very important concern (but options such as insurance mechanisms are being developed to deal with this issue); and
- care must be taken to ensure that there is no leakage. *[Note: This refers to indirect effects outside of the project that offset the gains of the practice, such as when afforestation in one area leads to increased crop productions (and GHG emissions) elsewhere.]*

Overall, there is a great deal of uncertainty, and real, measurable, and verifiable data are needed.

The barriers identified in her study included:

- the lack of enabling public policy (and corresponding political will);
- a limited understanding of both the range and the potential of various practices and technologies;
- the lack of credible measurements for these practices;
- a confusion among the different types of accounting standards; and
- the lack of a coherent, co-ordinated approach to address biological potentials (e.g., a standard set of measurement protocols).

So what is the "accounting criteria" bar? To be eligible for credits, a practice must: go beyond BAU and be surplus to existing regulations and incentives; be real, measurable, and quantifiable (this addresses leakage, uncertainty); be verifiable (by a qualified third party); protect against carbon reversals; and provide the same quantity or level of service as the practice it replaces. In the case of life cycle analyses (LCA), which she stated are necessary to meet the above criteria, it is necessary to go farther than "soils to farm gate", which tends to be the norm for agriculture. The whole life cycle must be considered.

She gave the example of a particular product—milk—and how the large multi-national companies that sell milk or milk products are using LCA to try to reduce their carbon footprints. About 70 per cent of milk's footprint is in the production stages (not including pre-farm impacts, such as fertilizer production). Such companies have deep pockets and are using their financial resources to develop tools that farmers can use to reduce their products' on-farm carbon footprints. She indicated that caution must be exercised, as the result of this exercise could simply be "green wash". She gave an example of a tool developed for Unilever called "The Cool Farm Tool," which is an on-line method for calculating these footprints and for estimating the result of changes in management practices.

Finally, Ms. Haugen-Kozyra outlined possible opportunities for Ontario. The first is the more efficient use of fertilizer, which could greatly reduce N_2O emissions in Ontario soils. The second involved converting wastes that would normally go into landfills into compost or biochar. She felt that this second opportunity not only provides the potential for carbon offsets from avoided methane emissions, but is likely the best one in Ontario with respect to soil-carbon sequestration.

QUESTIONS FROM THE AUDIENCE

and Ms. Haugen-Kozyra's answers

1. *Where do the 19 percent N_2O emissions in your pie chart come from—crop production or livestock systems?*
   If you change the feed that livestock receives, you can lower the nitrogen content in their manure. That means that you will get fewer N_2O emissions when that manure is applied to the soil.

2. *You mentioned a standardized baseline. A number of jurisdictions have struggled with the setting of thresholds for different variables, so that you know if the practice exceeds the baseline. Does Alberta have any experience with this?*
   It is more of a practice-based linkage, as in "are you implementing the practice correctly?". The standardized baseline is there, so it is the appropriate application of the practice that triggers the co-efficient. And that is where the verification comes in: a) are you using the right co-efficient? And, b) are you implementing the practice appropriately, so that it links back to the scientific work that supports it?

3. *This whole thing is a bit like Alice in Wonderland. The federal budget yesterday said nothing about climate and there is no political will to do anything for the next number of years. Also, the idea that Walmart or Unilever could lead the charge on the development of something that has to be bulletproof and fraud-proof is a bit absurd. This not to say that this process is not valuable. I think that Ontario farmers have an opportunity to do something that is value-based, mission-driven, and potentially real. We should look at that, rather than what Walmart wants.*
   She stated that she would let Don McCabe address these points. They work together on this and have been in the U.S. and heard these discussions and he is in a better position to talk about them. But she does applaud the efforts of the dairy industry in the U.S. because they have forged ahead and set their own standards and are taking their own actions. World Wildlife Fund is backing off, but you either have an incentive through something like this (and she is not sure that carbon is the right incentive) or the supply chain dictates to you.

4. *Could you talk about the protocols that were developed in Alberta and what you think needs to happen to have these protocols adapted for use in Ontario?*
   She said that she would focus on the N_2O emissions reduction protocol. It was developed using the same methodology that they were using when they were working collaboratively with Agriculture Canada and Environment Canada. They did a very careful review of the scientific literature and then worked with scientists to develop that IPCC Level 2 quantification "sweet spot." It was done for a national level but of course it had a bit of a prairie focus; they had their workshops in Alberta. They had a number of people there from the federal government and national organizations. It is all documented on their website; the process took 3 ½ years. The co-efficients are all there from the national emissions inventory and they worked partially on the implementation levels of the BMPs, but there is tweaking that needs to happen. It is based on risk management; essentially avoiding conditions that are conducive to N_2O production from the soils. These are known as the 4R's—the right product, at the right time, in the right place and the right rate—don't let the nitrate accumulate, so you want to apply ammonia sources, you want to band them sub-surfacely, apply only when the plant needs them, and you want to apply variable-rate technology based on landscape assessments. But there are unique things like tile drainage that need to be assessed here in Ontario. Also, those BMPs were notional; it was always assumed that there would need to be workshops here so that the Ontario folks could begin to work on those BMPs, to determine the performance levels that are right for Ontario.

5. *I am a little concerned about your BAU criteria. Isn't it going to penalize the traditional farmer who has a small footprint? For example, take grazing, as compared to a feedlot; the former is better, but the latter can put in an anaerobic digestor and get credits that the former can't get.*
   This is the hardest pill to swallow—this additionality. They have argued with people in the U.S. about that, because in agriculture it is assumed that it should happen this way because it is economical. However, they do have policy mechanisms that we have used to get around this problem. For instance, in adopting no-till, because they have spatially and temporally averaged quantification, based on modeling, they subtract the carbon that has been gained to date from previous no-tilling operations and the only carbon that is rewarded is the incremental carbon moving forward. So the early adopters benefit, the late adopters benefit but with a smaller co-efficient, because you are adjusting for that effort. So that proportional additionality is an example of the kinds of things that WCI and others are talking about.

Participants' Comments & Discussion on Session Three

While the roundtable seemed to generate a rough consensus that financial mechanisms of some sort are required to advance the cause of soil-carbon sequestration in Ontario, there was not complete agreement on which mechanisms are the best to put in place.

Many participants expressed support for the bundling concept described by Mr. Campbell. Bundling means that carbon is included as just one benefit in a group of ecosystem benefits provided by a given practice, with only one payment to the farmer. This can be contrasted with a carbon offset or credit system, where the farmer could be paid for sequestering carbon (say, by means of adopting an accredited BMP) but could also apply to some other source for a payment for a different ecosystem service (such as improved water quality, for instance) arising from the same BMP (this is what Mr. Campbell referred to as stacking).

While none of the participants directly opposed the concept of bundling, the question remained as to where the payment money would come from. Options floated during the session included:

- a carbon tax (with revenues going to support adoption of BMPs);
- government tax revenues (on the basis that all of society gains from the adoption of these practices);
- a charge on consumers (for the same reason); and
- the private sector (either by mandating the kinds of voluntary corporate initiatives described by Ms. Haugen-Kozyra or by placing a regulatory burden on industry that would create a larger offset market).

Several existing programs were held up by participants as good potential models. These included:

- the Alternative Land Use Services (ALUS) program, which is running in several parts of the country, including Ontario;
- the watershed-level water-quality programs being run by the Grand River Conservation Authority (GRCA); and
- the Environmental Farm Plan, which was seen by many as the ideal vehicle to deliver these and other initiatives related to soil carbon.

Other policy mechanisms that received support during the discussion included:

- incorporating BMPs into the insurance/safety net programs for farmers;
- start-up grants from government for BMP adopters;
- providing no-till tools to farmers;

- giving some kind of financial credit to farmers who adopt no-till practices;
- providing a means to aggregate credits at the watershed level;
- developing a framework for including the whole supply chain in programs; and
- developing and implementing many more educational tools and programs for farmers.

Other related opportunities were brought forward during this discussion. Participants mentioned the importance of:

- changing feeding strategies in feed lots;
- developing digital and infrared carbon-measuring technologies to help bring down administration costs;
- establishing more policies and programs to ensure the return of urban organic residues to farmlands;
- pursuing the potential of energy crops as a way of helping farmers, reducing fossil fuel use, and sequestering carbon in soils;
- providing farmers with predicted climate trends at local levels; and
- the further development of automated electronic templates for nutrient input management.

Participants were able to identify many different barriers to the rapid adoption of BMPs in Ontario. These included:

- a lack of awareness of the importance of soil by the public and by politicians;
- the lack of Ontario-specific scientifically validated protocols;
- the technical difficulties involved with soil-carbon measurement;
- the problem of permanence (when program ends, the practice stops and carbon is eventually released into the atmosphere);
- opportunity costs for farmers (time and resources that could be spent on production);
- penalization of early adopters (i.e., those already practicing a BMP do not get a payment);
- the high cost of administering these types of programs (these may exceed the financial benefit generated);
- non-point sources of any benefit are difficult to measure;
- a lack of resources: where will the funding come from?
- a lack of basic research and of subsequent university extension services;
- farmer resistance to change (human behavior);
- cheap municipal landfills (making them an alternative to compost production);
- the fact that up to 50 per cent of farmland is rented (assuming that renters have less incentive to improve land for the long term);
- no crop insurance for cover crops;
- low food prices (farmers have less revenue to work with and therefore less ability to invest in long-term soil improvement); and
- lack of political will.

Some of the more general advice put forward during these discussions included:

- Ontario needs more co-ordination between agencies in this regard;
- a one-stop-shopping system is needed for farmers (the U.S. Department of Agriculture website provides a good example);
- the current feed-in tariff (FIT) program for green energy, while a potential model for soil carbon, did not help to get farmer support because of the way in which it was implemented;
- the concept of payment for environmental goods and services (EGS) seems to make more sense for this particular issue than does the concept of carbon trading; and
- the idea of "launch and learn" should be adopted by the provincial government when it comes to soil carbon.

ECO OBSERVATIONS ON SESSION THREE

The ECO's interpretation of the overall themes regarding financial incentives was that:

- better tools are needed, including protocols for the most promising BMPs, in order to be able to compensate farmers for adopting them;
- better metrics are required (baseline data, measurement protocols, monitoring activities, etc.);
- an overall policy framework that takes the whole supply chain into account is needed;
- a bundled approach to ecological goods and services may be better than the carbon-credit or carbon-offset approaches;
- increased awareness of the value of soil at all levels, from the farm to the general public, is necessary;
- all actors in this field need to be co-ordinated, so that the farmer has one window to deal with; and
- despite all of the above challenges, efforts must begin as quickly as possible (launch and learn).

In addition, there was general agreement that society needs to share the risk with farmers as they move to more sustainable practices; however, the question that remains is how to share this risk most fairly and effectively.

SESSION FOUR

A Farmer's Perspective

Don McCabe | VICE-PRESIDENT, ONTARIO FEDERATION OF AGRICULTURE

Don McCabe provided the farmer's perspective on issues discussed at the roundtable.

Mr. McCabe began by saying that everybody needs to drop their personal agendas and turf-protecting activities, because the reality is that policies are being set at the international level and that they are going to have impacts, right down to the farm level. For farmers, the challenges are always the same: profitability, money, and economic return. Farmers agreed to do battle with Mother Nature, not with bad policy. The latter has led to food insecurity and climate change.

He showed a map of the world that indicated that many parts of the world (and North America) have low soil organic carbon levels. He argued that soil carbon has been ignored for too long.

BIO

Don McCabe has served as Vice President of the Ontario Federation of Agriculture (OFA) since 2008 and is in his third year as President of the Soil Conservation Council of Canada. A practicing no-till corn, soybean and wheat farmer based in Inwood, Ontario, McCabe also has a doctorate-level education in soil genesis and classification. He has been a leading advocate for environmental farm stewardship in the areas of air, water, biodiversity, and climate change.

With respect to policies and solutions, it must first be recognized that farms can be carbon sinks. Second, long-term research into crop and animal production is absolutely necessary and long-term should not mean just until the next government budget. Multi-year plots need to be established and maintained. Third, action on policy is required, not just discussion.

To this policy end, he stated that it is important to first really understand the definition of a farmer. Regardless of whether a farmer is growing cash crops or raising animals, they are doing the same thing: managing the carbon and nitrogen cycles in conjunction with the water cycle to produce starch, oil, protein, fuel, fibre and energy. At the same time, farmers are providing animal habitat, improving air and water quality, and conserving soil. They just need to get paid for something.

Mr. McCabe then said that carbon is a global issue requiring global solutions. Local initiatives can help, but the policy problem has to be addressed by governments globally and the federal government has to stop ducking its responsibilities.

He then discussed the carbon cycle in more depth. He believes that farmers are not going to use inputs that they don't need, nor are they going to pollute local water supplies. Reducing inputs is in everybody's interests. Farmers also know how to put carbon back in the ground; while the right technical means to measure this might not yet exist, they are almost in place. Let's not let perfection be the enemy of the good, he said. We all know that photosynthesis is the key and we have all heard today about what plant roots and soil biology can do. But research is necessary. Back from the time that Lincoln was in the White House until after the Depression, there were no increases in corn yields. Between the Green Revolution and other advances, Ontario farmers in 2010 set new records for yields. Since 1925, corn yields have increased from 20-30 bushels per acre to 150 bushels per acre. Research and good policies are needed because farmers live the cycles and impacts of policy.

Policy action must also be independent of scale. Cash crop farmers have to operate thousands of hectares to make money, while mixed farms can be much smaller and greenhouses smaller yet, although the per-unit-of-area investment is much higher. It doesn't matter, however, since all farmers count and farm organizations can be a vehicle for pilot and program delivery. Again, he emphasized that long-term research should not be measured by government program length.

He stated that policy makes markets and if the policy is not good, the markets won't be either. The Chicago Climate Exchange was voluntary; when economic times got tough, the money walked away. If they are required to comply, they will comply, which brings us to the concept of environmental goods and services (EGS). New York City, for instance, invested in 70,000 acres of land in two watersheds to provide clean water for eight million people. That has value because it is replacing infrastructure. Good policy incents good actions and good policy should incent investment by everyone, including institutions, international organizations, and, particularly, the private sector—because they have all the capital. He said "stop looking for excuses and start looking for answers."

Why do farmers care? Because it comes back to them as costs: for electricity, chemicals, fuel, fertilizer, and lime. They now have an opportunity to step up and make their voices heard, and to establish a new revenue stream. This will be a global issue, too, as harmonization will eventually be required.

Canadian agriculture is 10 per cent of the problem and 20 per cent of the solution. This applies to the province of Ontario. For example, tillage protocols were developed for all of Canada, including different soil types and climates. Some of the numbers are negative, but that just means that when someone has to reverse a practice, you take it off. He showed some pictures of what sustainability looks like on his farm. The pictures showed a field of winter wheat that was planted in the fall of 2008 after the 2008 soybean crop.

The wheat crop would be ready for harvest in the summer of 2009. A close-up view of the soil surface showed corn cobs from 2007 that had still not broken down. That tells him that the soil doesn't want them. At the same time, they have four times the energy of the corn kernels. Why not use them to make fuel? Bio-products are presenting some exciting new opportunities, he said.

Mr. McCabe provided his views on some of the points raised earlier in the day. He agreed with the comments made about humic and fulvic molecules (i.e., soil humus) being chemistry dinosaurs and added (in a direct comment to his colleagues at the University of Guelph) that poor sampling gets bad results. He disagreed that no-till does not sequester carbon. As for soil-carbon protocols, he said that perfection can't be allowed to be the enemy of the good, so we should get on with creating them as soon as possible. He said that he also heard (and agreed) that roots and soil life are keys to sequestration and that the latter is an ecosystem benefit. As for biochar, he feels that it is not needed in Ontario, but has use in developing countries with older soils. He also expressed impatience with the concept of indirect land use (as a barrier to developing protocols) and the idea that any kind of carbon payment is a subsidy. He asked if this was really a subsidy, or was it an investment of tax revenue in a natural resource (i.e., farmers)? He also asked how someone can double dip if there is no policy in place.

With respect to the question of annual payments, Mr. McCabe provided an analogy to annual salaries. He asked, for example, now that the Environmental Commissioner has worked in the job for 10 years, if perhaps he should stop being paid. The gist of his messages was: the benefits keep being delivered, so the payments should as well. He also heard that 70 per cent of the emissions come from behind the farm gate and that there has been a corporate response to this fact. He said that World Wildlife Fund (WWF) was not able to get the attention of government on this, but was able to find 15 commodities that it would directly address. He also mentioned the Cool Farm Tool and said that Agriculture and Agri-Food Canada has Holos, a similar system, but it needs to be updated and promoted *[Note: The Cool Farm Tool and Holos are on-line systems for calculating greenhouse gas emissions from farms].* He concluded this set of comments by saying that there are no silver bullets out there, but that there is a lot of silver buckshot.

In conclusion, Mr. McCabe showed some of the same data that Ms. Haugen-Kozyra showed, regarding the high potential for soil-carbon sequestration in mitigating climate change. He said the world is moving in this direction and that Ontario can choose to lead or it can delay for another ten years (ten years that the world cannot afford). In the end, soil is about many vital things, including water and air quality. Farmers can sequester carbon for the world, but they need the policy mechanisms to get it done. In the end, he says, it is only farmers, foresters, and ranchers that can take carbon out of the air and put it back in the soil, where it belongs; policies need to be put in place to look at paying for carbon sequestration as an environmental service.

QUESTIONS FROM THE AUDIENCE

and Mr. McCabe's answers

1. *A lot of the big companies, like Walmart, have figured out that they can save a lot of money by having their suppliers reduce the weight of what they send to them, often by eliminating much of the water content (e.g., concentrated product). How can they ask farmers to do something similar (i.e., reduce their carbon footprint) as suppliers, without providing them with the necessary infrastructure (whether that be in the form of a technology, or as financial assistance)?*
   There are too many accountants involved. What is needed is a systems approach, looking at the big picture, not just company dollars.

2. *How is agriculture going to handle the other side of the problem, which is peak oil and rising energy costs?*
   Rising energy costs will always be a concern, but already farmers all over the world are switching to alternative fuels such as natural gas. Some are even using steam-powered equipment, which with modern technology has come up to speed. In terms of nutrients, over in Denmark they are extracting phosphorus from Copenhagen's unsorted municipal waste. Between recycling and cover crops, we should be able to adapt. He is a firm believer that there are solutions, we just have to find them. Moreover, we are going to have to find them quickly, as the latest figures show that the world's population is growing even faster than had been expected, with 10.1 billion the projected figure for 2040 (rather than 9 billion by 2050).

3. *I agree with your comments about industry. As a potato grower in this province, I am having a problem with these companies that have looked at their environmental footprint and then come to us and said that they want us to use 30 per cent less water, reduce our inputs by 30 per cent, but deliver them the same quantity at the same price. When we ask them to tell us how we can do this we get blank stares. When we ask them to tell us how we can afford to do this, we get even blanker stares.*
   He replied, "Blank stares, but no blank checks, right?"

SESSION FIVE

Going Forward

Participants' Final Comments and Discussion

Participants were given an opportunity to make some final comments on what they saw as the next steps. The following is a summary of the views expressed.

- With regard to carbon offsets, the most important thing is to develop accurate and consistent methods for quantifying soil-carbon sequestration. For this approach, it is necessary to separate carbon sequestration from the other benefits associated with the adoption of the best management practices (BMPs).
- What is required is a multi-stakeholder working group to oversee the development of: methodologies (balancing accuracy with cost); standardized baselines; and the willingness of farmers to participate (can be determined by means of a survey). This would be the most democratic approach to the issue.
- The governments of Canada and Ontario need to be challenged directly on the issue of soil and food security. This challenge should feed off the Food and Agriculture Organization (FAO) global initiative on this subject. *[Note: the FAO of the United Nations has recently (2011) launched an initiative to convince governments around the world to officially adopt the provisions of a World Soil Charter "spelling out the basic principles and guidelines for sustainable soil management and soil protection to be followed by governments and international organizations." The Charter was originally created in 1982 but has gone largely unrecognized by governments to date.]*
- An *energy return on energy invested* perspective needs to be adopted. Doing so would create a secure soil system upon which a secure food system could be built.

- There is a need to go beyond agriculture when talking about soil. Soil should be elevated to its proper place in society (one of its basic foundations). The Environmental Commissioner of Ontario (ECO) should take a leadership role in this endeavour.
- Ontario should be far above the current level of ten percent food self-sufficiency. This should be a high priority.
- A focus should be placed on proven techniques for building soil carbon within conventional agriculture, rather than focusing on tangential issues such as biochar.
- The provincial government should have a local-food promotion policy.
- It is important to get the message across to universities that soil science research is a very important part of the movement to increase the carbon levels in Ontario soils.

Commissioner's Closing Remarks

In closing, the Commissioner noted that when he was a student at the University of Guelph many years ago, the definition of soil was "the living component of the geosphere." When he later was a professor at Sir Sanford Fleming College, he taught an environmental technologists' course alongside an engineer. The school thought its students should learn their material from both perspectives—the biological sciences as well as the engineering disciplines. At that time, he was still teaching the definition of soil he had learned at Guelph. For his engineering colleague, however, the definition of soil was "material that can be removed without blasting." The Commissioner commented that perhaps we have been moving too far in the direction of that latter definition in recent years and he was glad to see the presentations had emphasized the importance of the life in the soil.

He commented that the ECO's 2010/2011 Annual Report was called "Engaging Solutions" and that the gist of its message was that in Ontario we do a lot of talking about things, and even planning of things, but we don't DO anything. He said that he had just returned from the latest Globe conference where he had heard the Republican Governor of Oregon and the Premier of British Columbia talking about how their respective jurisdictions' actions in the area of sustainability were now driving their economies into the future. Everything they said was positive. Meanwhile, all that the Ontario people could do was say "yes, we want to hear visionary things too and we also want to do stuff."

What he heard during the roundtable was that perhaps as a province we are bogging down in the sphere of soil carbon and ecosystem services payments. Perhaps we are trying to be too perfect. On the other hand, in Alberta, he said, they appear to be going ahead with their less-than-perfect system and finding out what works and what doesn't. It has forced them to tackle some questions and get some answers. Their level of resolution is clearly higher than ours. As we still worry about questions like "what if this

happens?" they have simply gone ahead and found out. Wisdom, he said, is the result of the accumulation of a lifetime of mistakes.

He heard lots of discussion about how the precision was not there to create offsets, but neither is the cash. The real issue, he said, which perhaps is obvious, as most good ideas are, is the question of managing carbon as a resource in our economy. He stressed that he does not like the word waste (although the ECO does use it when necessary in context, such as when critiquing government waste-management programs). He prefers to talk about resources instead. Many of the carbon-rich materials in our society are not wastes, they are valuable resources. His reports have pointed this fact out many times. For example, in his 2009/2010 Annual Report, he stressed the under-appreciated value of municipal compost. The money from a carbon credit is not enough to drive the recovery of these resources, he said, though perhaps it could help. What is required is a combination of resource-based financial tools, such as tipping fees and resource prices.

Why aren't we doing this in Ontario? Well, perhaps we are in a way, he said, but with the emphasis on energy and the *Green Energy Act* and the FIT contracts, a lot of carbon-rich materials are going into energy production. If we have the money to do this, he said, perhaps we are just not being sophisticated enough, perhaps we should be expanding this resource-management system to ensure that we not only get energy, but that we close the loop completely and get the organic residuals back to the land. So this concept was something that got him thinking, and after all, that was the intent of this roundtable—to get people thinking and talking about this issue. Perhaps the previous speaker was right, he said, in that there are too many vested interests and people protecting turf on this issue; however, it is time to break down the way that we think about these things and to open up our perspectives to new ideas.

He thanked everybody for their contributions and concluded that it had been a long, but a very rich, day.

ECO COMMENT

The Commissioner's Roundtable generated a raft of thoughtful, sometimes even inspiring, points of view with respect to both the opportunities and the challenges associated with increasing soil carbon, building healthy soils, and ultimately, ensuring soil and food security for Ontarians. The ECO was very pleased with the enthusiasm and the level of importance obviously accorded to this issue by the participants. A main goal of the roundtable was to promote a province-wide, multi-sectoral conversation on this vitally important subject. Now that this conversation has commenced, it will hopefully continue into the future. The subject is too important to remain under the radar, as has long been the case.

Several vital points emerged from the roundtable. First and foremost is the need for more and better metrics; what can't be measured can't be properly managed. Ontario needs to have a much better idea of the state of its soils, including levels of organic matter and rates of erosion. To do this, more accurate and cost-effective measurement tools are needed, including both high-tech technologies, such as remote sensing, and simpler, in-the-field systems that farmers can use. Protocols for our most promising BMPs are required. Since these often take a few years to develop, they must be started as soon as possible. As one participant suggested, the formation of a multi-sectoral working group to oversee this work would be ideal.

Secondly, more research is needed. The work done by Ontario's Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and the University of Guelph is a very good start, but much more work remains. As was pointed out fairly clearly by the final speaker, these research programs must be long term if they are to be worthwhile; they can't be the first target of every round of budget cuts. This work must be the basis for the development of the BMP protocols required for any type of long-term payment system. Also, despite the reservations of some of the roundtable participants, the ECO feels that this research must be expanded into the area of soil ecology and its application to sustainable agriculture. This field offers the potential of new and valuable understanding and sophisticated scientific tools for ensuring sustainable production, soil health, and enhanced carbon sequestration. Nor should the intriguing potential of biochar be ignored. Ontario may have relatively young and fertile soils, but anything that offers the potential for reduced fertilizer use (without sacrificing yield), an enhanced soil food web, and long-term soil-carbon sequestration, should get a long, hard look by government-sponsored researchers.

Finally, with respect to the issue of financial incentives, the ECO shares the frustration felt by many on this matter. All of the BMPs discussed at the roundtable, and many other emerging ones as well, provide a number of agricultural, environmental, economic, and social benefits in addition to sequestering carbon. Do we need to wait until we can measure the carbon sequestered with a high degree of accuracy and dependability before we implement incentive programs? The ECO does not think so. In fact, Ontario could use the time required to develop and refine measurement tools and protocols to simultaneously develop, implement, and refine preferred incentive tools. The ECO suggests that the "launch and learn" approach is not only appropriate in this case, but is absolutely necessary.

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