How Will Your Farm Cope With A Changing Climate?
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Global warming is a reality. The vast majority of scientists believe it is happening and that human activities are a primary cause, that what we are experiencing is not just a product of natural forces. In fact, food production and distribution are two of the most significant contributing factors. And now, this reality is coming back to haunt farmers. Unfortunately, many farmers appear to be overly confident in their ability to adapt to a changing climate[1], remembering earlier successes adapting to periodic shifts in weather patterns. The key question for agriculture will be whether adaptation will be predominantly planned or reactive. Producer interviews and focus groups reveal that to date there is generally little concern in the Canadian Agricultural community regarding climate change. These attitudes have been attributed to the confidence of producers in their ability to adapt to changing climatic conditions, and their tendency to be more concerned with political and economic factors. Numerous studies have demonstrated that financial and economic concerns are the primary influence on producer decision making. This does not mean that adaptation will not occur, but rather suggests that climate change adaptations will be incidental to other adaptations, and should be viewed as one element of an overall risk management strategy (pg.64, Climate Change Impacts and Adaptation: A Canadian Perspective). However as this briefing note outlines, the extent of adaptations that will be required to respond to the effects of climate change will require a major redesign of the farming system. This redesign will be more difficult to undertake the longer a landowner waits to start making changes. Therefore it is imperative to develop a communication strategy with the farming community that will emphasize both the impacts of climate change that can be expected and the need to design adaptations in a systematic way. Many organic farmers think that they will be protected from the effects of climate change, and relative to conventional farmers they will likely be more resilient. But climate change will be so significant that all farmers need to re-assess their farming system.

What is global warming doing to the weather? Here’s what’s predicted for the Lake Huron region[2]

Global warming is altering weather patterns in different ways all over the globe. In the Lake Huron region, the following changes are projected:

- Average temperatures to increase by at least 3 - 6 degrees Celsius over the next 40-50 years. But those increases will not be gradual. From year to year there will likely be dramatic fluctuations in temperatures which will make it more difficult for plants and animals to gradually adapt to the changes.
- Seasonally, temperatures are projected to increase the most during winter to the point where the average winter temperature would be above 0 degrees Celsius
- Annual precipitation is projected to decrease by 4% on average
- Precipitation levels may increase in the spring and fall by as much as 30% and summer and winter levels could decrease by as much as 30%
- Less wintertime precipitation may fall as snow and more as rain. Less snow usually means less water storage. This will likely reduce stream flow in the summer and fall and produce higher flows in the spring and winter.

The Maitland Valley Conservation Authority (MVCA) has been reviewing the climate data that they have collected from their weather stations over the last 40 years. They have identified the following trends which foreshadow the changes we are likely to see:

- A change in precipitation patterns to more isolated, short duration, high intensity rainfall events (more scattered thunderstorms).
- More rainfall events of only 25mm of rain at a time or less.
- Annual precipitation for the watershed is up by an average of 27 mm per year from 1951 to 1990.
- More of this extra rainfall is getting to the rivers and streams as there is a steady increase in water flowing down local rivers on an annual basis.

Additionally, the region will likely see more ice storms, lake effect snow events, shifting of thunderstorms into spring and fall, and more extreme wind events.

What does this mean for farming in our areas?[3]

The MVCA thinks that, because we are having more intense rainfall events, this will increase the potential for soil erosion on agricultural land, and more stream/ditch bank erosion, leading to higher sediment loads in watershed rivers and streams. As well, farmers are likely to experience:

- Drier summers and falls - in effect, more distinct wet and dry seasons and more trouble matching crop moisture needs with moisture availability
- More problems with soils with relatively low moisture capacity (sandy/silty soils)
- More crop damage from extreme weather events, including wind
- More water quality problems, including those related to increased erosion, associated with extreme weather events
- A decrease in yields for major crops grown in Ontario due to lack of moisture (projections are that barley and corn yield could decrease as much as 20%, soybeans by as much as 12% and wheat by 27%). Some scientists think that carbon dioxide enrichment in the atmosphere will actually result in increased yields for many crops. This might be true if average temperature increases were contained below 1-3 degrees C, but most studies suggest the temperature rise will significantly exceed that level (IPCC adaptation summary). However, given the higher temperatures associated with this added CO2, it is likely that higher evapo-transpiration and lower water availability, combined with additional pest and weed pressures, will result in minimal yield benefits[4].
- More stress on animals associated with extreme weather events. Although milder winters may improve feed conversion efficiency, drier, hotter and even windier summers will likely cancel out those benefits. Dairy animals and poultry are thought to be most vulnerable to negative production impacts associated with heat stress. Drought may force producers to reduce stocking rates. Extreme weather may also increase the number of power outages, which may result in production losses[5].

How farmers can adapt to increased climatic variability

Adaptation will be essential because we will not be able to mitigate emissions fast enough to turn the situation around quickly. It is generally agreed that our agricultural economy will suffer unless adaptation measures are widely adopted[6].

Environment Canada has published a report titled 'Adapting to Climate Variability and Change in Ontario'. The report points to a greater need to adopt practices in all sectors of the economy that will help to conserve water and protect the health and resiliency of our river systems, prime agricultural land and remaining forests. Some of the major adaptations that are recommended in the report are:

- adoption of conservation tillage practices,
- rotations that include cover crops,
- conversion of agricultural land with low moisture retention capacity to other uses,
- planting of more wind breaks/shelter belts and hedgerows,
- agro forestry (inter planting trees and crops),
- increasing forest cover in headwater areas, river valleys, flood plains and stream corridors to help retain runoff and summer base flow, and
- limiting irrigation from rivers and streams to protect base flow during the summer and fall periods.

The key challenge is to design farms so that water storage and movement are not unduly compromised by the combination of extreme heat, drought and variable rainfall patterns. Many farms have significant periods of the year with minimal soil cover, inadequate soil organic matter levels, high levels of compaction, and drainage systems that are more likely to take away excess water rather than conserve it. All these conditions are likely to lead to reduced capacity to adapt to climate variability. There are many agronomic management strategies proposed for increasing one's capacity to adapt, some of which include cropping systems, conservation tillage, changing seeding and planting dates, changing varieties and keeping stubble higher to trap moisture. Larger landscape management strategies are also critical. We describe here a few that appear to be most promising:

Cropping systems and conservation tillage

There are a spectrum of cropping system strategies farmers can employ to increase their resilience and flexibility in the face of climate variability. At the more resilient end of the spectrum are complex crop rotations characterized by significant use of green manures, intercrops and legumes, reduced tillage, deep and extensive root masses, high soil organic matter levels, and good soil tilth.

Studies from the U.S. mid-west, examining corn, soybean, and wheat systems reveal that longer rotations involving legumes leave farms better able to withstand drought[7]. One series of studies from the University of Nebraska showed that the longer rotations reduced the risks of suffering through a bad year, and resulted in less variable net returns[8]. These longer rotation systems have consistently performed as well or better than short corn - soybean rotations.

What accounts for this ability of longer rotations to withstand uneven weather? It is thought to be some combination of root development and soil tilth. Studies support the idea that it is important to include perennials when possible. It is advisable to choose crops with extensive root systems, as many crop root systems contain higher levels of carbon than above-ground biomass. One study has shown that roots in cropping systems with perennials have 1.6 times more bound CO_2 than roots in short rotation annual systems; this difference is mostly associated with legumes such as alfalfa and red clover[9]. Soil organic matter content is a critical feature. However, while critical, organic matter content does not necessarily have a direct impact on moisture retention, as much as soil tilth. Organic matter, especially in loamy soils, can improve soil aggregation. Aggregation creates more pore space for root movement. Although the traditional view is that the kind of organic matter is less significant than the quantity, it is actually the kind that really matters. The more digested organic matter fractions appear to be the most significant for soil tilth and moisture retention - microbial gums and mucilages, low molecular weight fulvic acid molecules, and fats and waxes[10]. Drinkwater et al. in their study contrasting conventional and alternative corn - soybean cropping systems in Pennsylvania, found that longer rotations involving leguminous plants did not necessarily add more total organic matter to the soil, but because of the lower carbon to nitrogen ratio additions resulted in greater organic carbon sequestration and improved soil physical properties[11]. An Ontario study following different rotations over a 20 year period also found higher carbon sequestration with rotations involving alfalfa compared to conventional corn and corn-soybean rotations[12].

It appears that certain kinds of crop rotations will make greater contributions to these forms of organic matter than others. Systems that leave a lot of high carbon:nitrogen ratio material (e.g., post harvest crop residue) are less likely to provide the right kind of organic material for building soil aggregates than lower C:N ratio (less mature) material.

Soil cover

Winter plant cover is critical when there is so little snow on the ground and regular freezing – thawing cycles are the norm. In the absence of such cover, wind and water erosion will probably increase during extreme events. Although pastures may seem protected, good pasture management, to prevent both overgrazing and compaction from animal traffic, will also be essential.

Tillage

To be more resilient in the face of climate variability, tillage operations must strike a balance between organic matter decomposition, weed control and moisture retention. With steady and significant additions of organic matter, tillage is important at key times for accelerating the creation of organic matter fractions that promote aggregation and tilth. Too much tillage, however, will result in breakdown of soil tilth more rapidly than aggregates can be created and stabilized. It will also dry out the soil, so tillage for weed control must be balanced with cover cropping and mulching.

Conservation tillage is important, but traditional no-till systems may not actually be the best for balancing all these needs. Although no till is probably the most moisture conserving, the organic matter increases may not be composed of the right type and sizes of organic matter that contribute to the soil aggregate formation and stability. As well, there is some evidence that no-till systems may suppress root formation at deeper levels in the soil because the soils are often cooler and denser[13]. This is significant because a lot of soil carbon formation actually happens in the root zone below the top few inches. The reliance on herbicides in no-till systems is also problematic, since herbicides are less effective in dry conditions. Mechanical tillage, although contributing to soil drying, is still often a more effective strategy than herbicides under droughty conditions. No-till systems are also known to channel water (mostly through earthworm channels) quickly out of the root zones, making the water less available.

All this means that strategic tillage - limited but regular incorporation of a wide range of types of organic material at key times of the year - may be the way to go.

Agro forestry

Forest cover is extremely important for maintaining water cycles, but also has even wider benefits in the climate change story. A Michigan study looking at a range of cropping systems found that two perennial crops (alfalfa and poplars) added more carbon to the soil than any cropping systems. The alfalfa results have been confirmed in an Ontario study as well[14]. As well, native plant communities of all stages – early, mid- and late successional forests - had much lower green house gas emissions than conventionally farmed lands; and, in fact, most were net emissions sinks, which speaks both to their mitigation potential and their resilience[15].

The incorporation of agroforestry techniques into the farming system may provide a solution, by allowing farmers to generate financial benefits in the short to mid-term. Agroforestry is an approach to land use that incorporates trees into farming systems. It allows for the production of trees and crops/animals from the same piece of land, in order to obtain economic, environmental and cultural benefits[16]. Agroforestry has many applications, including windbreak systems, silvopastural systems where trees and animals are integrated, intercropping of trees and plants (e.g., walnuts with wheat, soybeans and hay), integrated riparian management systems to control stream bank erosion, and forest farming.

Shelter belts and hedge rows have long been used to modify microclimates around fields. Properly designed, they reduce evapo-transpiration from plant and soil surfaces. They consequently often result in yield increases relative to conventional practice, while occupying around 7% of the land area. The key is to design 'wind filters'[17] that don't block the wind and create lees, but rather filter it. Deciduous trees may be better because they transpire more moisture into the passing winds than do conifers.

Research at the University of Guelph on Ontario systems has revealed that tree - cereal crop intercropping systems can be managed to reduce competitive interactions and augment complementary ones, resulting in economic benefits to farmers. Nitrogen is transferred to adjacent crops from tree leaf fall, soil organic carbon increases by up to 30% relative to monocultural systems, nitrate loading to streams is reduced by half, and earthworm populations are augmented. In drought years they've found that these tree intercrop systems increase yield 100% compared to conventional cropping systems because the trees help retain ground moisture.

A Grand Valley farmer has planted rows of black walnuts with corn, grain and hay. As the trees grow, he envisions the tree - hay acreage becoming pasture for heifers. A Brighton farmer has planted 20 acres of walnuts in rows 50 feet apart and grows spring grain, hay and corn between the rows. Others have used corn as a nurse crop for high value trees. They all claim it's profitable and can't understand why more farmers don't practice agroforestry[18]. A further variant on this strategy would be to plant trees or other perennial plants within fields, rather than conversion of entire fields or areas. There is some Canadian evidence to show that it is more profitable/cost-effective to set aside marginally productive lands within fields rather than keep them in cropping. Setting aside these areas would reduce GHG emissions, sequester carbon and provide wildlife benefits as well[19].

Protecting riparian zones, headwater areas, river valleys, flood plains and stream corridors

For water management, these areas:

- Play an integral part in the water cycle.
- Slow runoff and reduce local and downstream erosion and flooding.
- Act as natural filters by capturing sediments, neutralizing contaminants and purifying water.
- Recharge groundwater sources for wells.
- Provide water for irrigation, livestock and crop spraying.
- Have plant communities surrounding them that provide a source of hay, help control the spread of salts into crop land, reduce erosion and trap snow in the winter, reduce sedimentation in streams and can lengthen the economic life of reservoirs, canals, and recreational lakes.

Some researchers now think that our failure to protect such areas is a major reason why farms are significant contributors to climate change and so vulnerable to its effects[20].

Stormwater management

When intense thunderstorm events occur, you need to ensure that you have pathways in place to funnel the runoff to an outlet without eroding the soil. A key strategy will be the development of a stormwater management system for the farm. This strategy should identify the pathways that runoff will follow from all parts of the farm to where it will empty into a watercourse. Collecting, detaining and gradually outletting the water from these huge events will be a central strategy for managing the effects of intense thunderstorms and rapid snow melt events. Properly designed grass waterways, stormwater detention areas and outlets are essential components of a stormwater management plan if farmers are to prevent valuable soil from being washed off their farms and into watercourses. This strategy will also reduce the frequency of cleanouts of open drains.

Some farmers have been doing the opposite of what's advisable - using the dry weather to drain marginal lands that act as natural stormwater detention areas and bring them into production. The conversion of these important areas eliminates the ability of those lands to function as natural stormwater detention areas, which will result in increased runoff and erosion during severe storm events. So landowners will lose both ways - increased erosion and runoff and low productivity on the lands they clear and drain.

Can you make it pay?

The studies generally suggest that increasing your farm's ability to adapt can pay, both short-term and long-term and the key is to find the right set of management changes. For example, the Ontario study[21] suggests that the payoff comes in more diverse rotations rather than in tillage changes. The possibility of shorter-term payoffs relative to long-term ones can be increased with more targeted and integrated approaches, e.g., intercropping trees and crops, or focusing on specific parts of fields rather than entire fields. Since the kinds of adaptation proposed here also help with mitigation[22], if government programmes reward farmers to mitigate, there will be an additional payoff for those implementing adaptation strategies. There will also be substantial savings in clean up costs. If damage from extreme events can be avoided, overall costs will go down significantly.

Conclusions

Whether your farming system is organic or conventional, you will not be immune to the effects of climate change. You will need to decide what changes you should make to your farming system to cope with an increasingly variable climate. Focus on your experiences of drought and heavy rainfall and imagine the implications of seasons characterized by these two extremes. Is the soil quality on your farm sufficient to provide some buffering of these extremes? Do you manage the water resources on your farm to give you maximum resilience? Are you properly managing your natural features - forested areas, riparian zones, ponds and watercourses - to protect the quality and quantity of your water supply? Does your livestock management contribute to or detract from your ability to manage under extreme weather? And are farm organizations doing enough to help their members prepare and putting enough pressure on governments to assist with those preparations? Farmers have always talked about the weather. It's time to think about how you will need to adapt your farming system to a changing climate!

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