POLICY BRIEF

Enabling Transformation of Two Farming Systems in Ontario's Changing Climate

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Box 1: Key Messages

- New research to understand the climate change implications for forage-based beef production in Ontario's Great Clay Belt and corn production in southwestern Ontario indicates that both regions and production systems will face opportunities, as well as risks.
- Adaptive measures include best management practices and alternative crop choices producers are already familiar with. However, "no-regrets", incremental changes will not always suffice. Large-scale transformations of production systems will also be necessary.
- The Government of Ontario can take a leadership role in transforming production systems to boost resilience to climate change. Strategies to do this will include understanding adaptive capacity locally within farming communities, providing opportunities for enhanced collaboration among land users and applying systems thinking to anticipate and correct institutional barriers to action.

Introduction

Adapting to climate variability and change can be achieved through effective management and conservation of soil, water and land at the farm-level[1], but, are there limits to this approach as climate change intensifies? How can Ontario responsibly take advantage of the longer growing seasons, increasing growing degree days and crop heat units expected in some parts of the province? This policy brief presents results from analysis of climate change risks and opportunities in two production systems in Ontario. It describes the concept and example applications of transformational adaptation to climate change, as an approach to navigate opportunities and risks in the long-term. Future considerations offer insights into how provincial policy advisors and program managers can enable the successful transformation of production systems in anticipation of future climate change impacts.

This policy brief is an output of a two-year research project to develop and pilot the Ontario Climate and Agriculture Assessment Framework (OCAAF). The OCAAF is a spatially-explicit, decision-support tool for application at regional scales to assess baseline and future agro-climatic risks and opportunities. The overall purpose of OCAAF is to inform the policy, program and management choices of key stakeholders in Ontario's agri-food sector, so as to maintain or enhance agricultural productivity under a changing climate. Funding support for its development and application came from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) through its New Directions Research Program.

Improving Knowledge of Climate Change Risks and Opportunities to Ontario's Agriculture and Agri-food Sector

In Ontario and across the nation, farming and related industries are core to economic development and rural livelihoods.[2,3] A changing climate creates both risks and opportunities for the sector. In Ontario, growing seasons are becoming longer and warmer suggesting the potential for northward expansion and creating opportunities for new crop varieties.[4,5] However, warmer summers and increased heat units can also contribute to water stress, caused by an increase in evaporation and evapotranspiration.

Extreme events, such as hail, intense downpours and drought, are likely to become more frequent and/or intense in the future. In areas presenting poor drainage and soil structure, a gradual rise in average spring precipitation may combine with the occurrence of intense downpours and rain-on-snow events to exacerbate risks related to soil health, erosion control and nutrient runoff.

Since the specific risks and opportunities of climate change on agriculture are locally variable, understanding the relative vulnerability of different crops and production systems across sub-regions in Ontario is important. Spatially-explicit tools to assess landscape-climate interactions and inform strategic adaptation choices are in short supply and do not yet include the most recent climate science. The Ontario Climate and Agriculture Assessment Framework (OCAAF) helps address this gap (see Box 2).

The initial design of the OCAAF was tested and refined through application to two distinct areas and production systems in Ontario:

1) Forage-based beef production in Ontario's Great Clay Belt, specifically looking at timothy grass; and
2) Corn production in southwestern Ontario, specifically looking at eco-district 7E-1.

Its pilot application to two distinct areas and production systems show how attributes of climate change may affect agricultural opportunities and productivity in the 2020s, 2030s, 2040s and 2050s. See Table 1 for a summary of the OCAAF results for the 2050s, aggregated to the sub-regional level (full results are available online at: www.climateontario.ca/p_OCAAF.php).

Figure 1: Timothy grass (Photo credit: Stang's Farm).

Box 2: What is the OCAAF?

The OCAAF is a spatially-explicit, decision-support tool to assess baseline and future agro-climatic risks and opportunities. It uses outputs of Global Climate Models (GCMs) to understand future crop suitability, as measured in growing degree days (GDD), crop heat units (CHU), potential evaporation (PE) and yield.

By building on the Land Suitability Rating System (LSRS) developed by Agriculture and Agri-Food Canada the OCAAF can also give a land suitability rating score. The LSRS is a well-established system that assesses the suitability of land for crop production, based on measurable qualities of three key factors: climate, soil and landform. The OCAAF updates the climate factors component of the LSRS and takes into account climatic-developmental requirements of the two crops studied.

Table 1: Summary of OCAAF results for the 2050s, aggregated to the sub-regional level

Indicator	Timothy (*Phleum pretense*) in the Great Clay Belt	Grain corn in southwestern Ontario (eco-district 7E-1)
Projected temperature for the 2050s, compared to a 1981-2010 baseline.	• Annual: +2.9°C • Winter: +4.7°C • Spring: +3.2°C • Summer: +3.2°C • Autumn: +3.3°C	• Annual: +3.3°C • Winter: +3.6°C • Spring: +2.8°C • Summer: +3.2°C • Autumn: +3.1°C
Projected precipitation for the 2050s, compared to a 1981-2010 baseline.	• Annual: +9% • Winter: +19% • Spring: +15% • Summer: +1% • Autumn: +7%	• Annual: +6% • Winter: +13% • Spring: +13% • Summer: no change • Autumn: +3%
Growing season length for the 2050s, compared to current season length.	+50 days	+28 days
Growing Degree Day 5 for the 2050s, compared to a 1981-2010 baseline.	+566 40% increase Triple cutting possible	n/a
Crop heat units for the 2050s, compared to a 1981-2010 baseline.	n/a	+390 25% increase
Potential evaporation between May and September for the 2050s, compared to a 1981-2010 baseline.	+58mm 13% increase	+88mm 16% increase
Land Suitability Rating System (LSRS) score for the 2050s, compared to a 1981-2010 baseline.	Shift from mostly Class-5 (very severe limitations) to Class-3 (moderate limitations)	Decrease from Class-1 (no limitations) to Class-2 (slight limitations)
Yield (kg/ha) for the 2050s, based on the historical relationship between yield and growing degree days (for timothy), and yield and crop heat units (for corn).	+2,160 30% increase	+3,300 41% increase

Yield projections for both production systems and sub-regions appear promising, even without taking into account improved inputs, management and supporting infrastructure. Opportunities to increase production in the Great Clay Belt are particularly notable. The actual extent of timothy production within the Great Clay Belt is uncertain and much of it is not arable at present due to the landscape. Nevertheless, hypothetical estimates of total yield potential for the Great Clay Belt can be derived by making assumptions of proportions of land cover under timothy production (see Table 2). These estimates do not include implementation of adaptation options, such as tile drainage, land clearing and improved transportation access routes. Considering the projected changes in favourable climate conditions, along with improved management, and projected yields in timothy forage, the opportunity to intensify forage-based beef production in the Great Clay Belt is apparent.

In comparison, opportunities to intensify grain corn production in Southwestern Ontario are more measured. Information on corn hectarage under production in 2011 in the eco-district 7E-1 served to estimate total yield for the region historically and going forward, assuming no change in area farmed (see Table 3). Yield projections near 50% by the 2050s are optimistic, since estimates do not account for the increasing challenge of moisture availability in summer months due to evaporation. Nevertheless, it is very likely that increased heat availability would increase yields significantly in a changing climate, even under heightened moisture stress and especially with the adoption of adaptive measures (e.g., irrigation).

Table 2: Great Clay Belt potential total yield/year under varying percent planted assumptions.

Clay Belt Extent		Production ('000 tonnes) per year				
Area (ha)	% Planted	1981-2010	2020s	2030s	2040s	2050s
830,400	20%	6,822	7,780	8,198	8,667	9,264
2,076,000	50%	17,055	19,450	20,496	21,668	23,160
2,906,400	70%	23,877	27,229	28,694	30,335	32,424
3,736,800	90%	30,699	35,009	36,892	39,002	41,688

Table 3: Average annual yield in tonnes for corn for 1981-2010 (baseline) and projected out to 2050.

Southwestern Ontario Yield (tonnes)	1981-2010	2020s	2030s	2040s	2050s
Assuming no change in area	172,491	208,458	224,274	239,398	258,889

Faced with the prospect of enhanced crop production in two Ontario sub-regions and production systems, important questions arise on how to responsibly exploit potential opportunities of climate change. Stakeholder discussions during two outreach workshops over the course of the OCAAF research project shed light on uncertainties and potential trade-offs to consider in developing adaptation strategies for the long term:

Forage in the Great Clay Belt

- Drawing producers to the area.
- Access to crown land and clearing of the land.
- Making best use of previously-farmed private land left fallow.
- Development of off-farm infrastructure, such as broadband internet, roads, bridges and drains.
- Development of local markets (e.g., slaughter capacity and restrictions on abattoir licensing).
- Development of social infrastructure, such as health care, education, cultural and faith-based services.
- Harmonization between Ontario and Quebec (e.g., regulations on the beef sector, language).

Corn in Southwestern Ontario

- Threshold beyond which reliance on rain is no longer optimal.
- Governance to allow for adoption of irrigation and communal use of water on farms.
- Sharing risk at the sub-watershed level, among the range of stakeholders affected by climate change impacts.

Transformational Adaptation to Climate Change

The ability to anticipate changes in climate conditions decades into the future opens up the range of options available to adapt.[7] The ability to distinguish a climate change signal from the noise of seasonal or year-to-year variability is limited in the near-term. Adaptation in this case typically focuses on managing known risks, by incrementally modifying existing actions or behaviours such as technological fixes, expanding crop and livestock variety, or water and soil management practices.[8] Supports for incremental adaptation by producer, for example, include provision or information, guidance on best management practices (BMPs) and access to business risk management programs. Incremental adaptation, however, may be insufficient to keep up with rapid or intense levels of climate change.

Transformational adaptation offers the possibility of navigating change on a much larger scale or intensity, and can include wholesale reconfigurations of production systems and significant changes in land use.[6,7] Whereas incremental adaptation is responsive to near-term changes, transformational adaptation is anticipatory and focuses on long-term solutions.[8] Supports for transformational adaptation include forward-looking investments in infrastructure, migration and re-training. Figure 2 illustrates the varied levels of adaptation, from incremental to transformational. In reality a degree of overlap exists across them, as incremental forms of changes can feed larger-scale changes.[9]

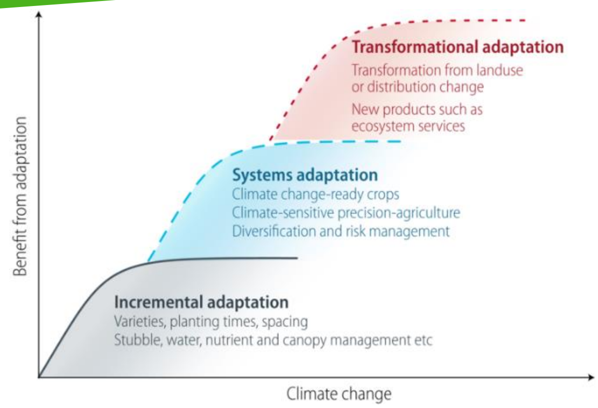

Figure 2: Levels of adaptation[6] and related examples.

Although the benefits of transformational adaptation are high, the transition costs and risks of getting it wrong can be as well. The impacts of climate change can appear unimaginable at present. Making the business case for investing in transformation, especially untested activities with benefits not seen until well into the future, can be challenging.[10] Transformational adaptation will benefit from building adaptive capacity, particularly the capacity to envision and prepare for unknown unknowns as well as the ability to promote shared learning across stakeholders. Learning from producers and rural communities as to their needs, aspirations and knowledge in adapting to climate change is especially important. Producers and rural communities are particularly sensitive to environmental and economic transformations because their livelihoods depend on the health of ecosystems and social connections.[1, 11]

Transformational Adaptation in Practice

Transformational adaptation is already afoot around the world. The drought-prone area of West Africa, the Sahel region, has always dealt with difficult agricultural conditions due to low rainfall and frequent droughts.[12] In the 1980s farmers began to adopt the technique of allowing the web of tree roots beneath their fields to grow – so-called "farmer-managed natural regeneration". Previously treated as weeds, the roots now develop into a scattering of trees among the fields that provide food, animal fodder, fuel and crop protection from wind and evaporation. The cumulative action of individual farmers to combat woodland loss has developed into a large-scale land transformation, approximately 5 million hectares of land now forms a greenbelt in this vulnerable area.[10]

In Australia, grape growers have been negatively affected by climate change, forcing them to take transformational shifts. Grape production in increasingly undesirable agro-climatic regions is slowing as contracts are terminated early or not renewed by wine producers. An alternative for some farmers has been to move their production to cooler regions of the continent such as Tasmania. Small-scale grape producers are also choosing the transformational options of land-use change, by converting to a different crop species, undertaking additional on and off-farm income generating activities, or reducing production until social, economic or climatic conditions are more favourable. The combination of a broad range of business models, adaptation strategies and agro-climatic regions involved in the wine production industry in Australia offers a high level of adaptive capacity overall.[13]

In Ontario, transformation in wine production is starting to take place. Wine production is an agricultural industry that is extremely sensitive to climatic changes. The Niagara and Prince Edward County areas of Ontario are prosperous viticulture areas due to the moderating effect of Lake Ontario and Lake Erie. However, significant fluctuations in winter temperatures have led to poor yields in recent years.[14] The Ontario Grapevine and Wine Research Network (OGWRN) is working with Brock University to develop several transformational strategies, including an assessment and mobilization of the adaptive capacity of the industry to optimize operations as conditions change over the next 30 years.[14] This includes the use of regional climatic models to identify new regions in northern Ontario suitable for quality winegrape production.[15]

Future Considerations

Of the two farming systems investigated in the OCAAF research project, transformational adaptation is most immediately relevant to forage-based beef production in the Great Clay Belt. Implementation of the Growth Plan for Northern Ontario (2011) provides an opportunity to reflect on the need, conduct research and consultation as to a collective vision and assets and capacities to build on, and put in place measures to prepare for the scale of change required for deliberate transformation.[16] Recent scholarship on transformational adaptation recommends building three sets of capacities as a way to enable successful transitions.[16] OMAFRA along with other provincial ministries, Agriculture and Agri-Food Canada, industry associations and local rural organizations should consider how best to build up these capacities in order to create a vision for northern agri-food that is resilient to climate change and consistent with social, economic and environmental values of the farming and rural communities affected.

1. **Capacity for systems thinking**. This is the ability to recognize interconnections across stakeholders, components of the production system, trends, conditions and power structures that affect its evolution. A number of tools exist to support systems mapping and develop a holistic plan for transformational adaptation, such as the examples shown in Table 4.[17]

2. **Capacity for leadership**. This includes the capacity to dedicate time to attend short-term issues as well as activities focused on future resilience. It involves the ability to navigate between details of current activities and keep the bigger picture in perspective. It also requires a degree of comfort with uncertainty and the organizational backing to take risks.

Figure 4: Tools to support system mapping and develop a holistic plan for transformational adaptation.

Tool	Action
Forecasting	Understanding current trends, variables, future situations.
Scenario building	Create a vision for a sustainable future, a tool to support adaptive planning. Identify uncertain forces and knowledge about future change.
Roadmapping	Developed through organizational-planning, shows connections of different developments over time and into the future.
Backcasting	Starts with a shared future of a sustainable future and then sets strategic milestone to facilitate on-going adaptations.

3. Capacity to learn from practice. This includes the discipline to engage in reflective practice, learn from experience and be able to reframe problems and apply insights to develop new approaches. This also includes cultivating mechanisms to listen to a diversity of local actors most directly affected by shifting weather, climate and other stressors. In combination, these three capacities will help identify institutional barriers and enablers to transformation that governments may be in good position to address.

In conclusion, results from the OCAAF project have illustrated the potential opportunities to intensify and expand agricultural production in two areas of Ontario. The most significant changes in growing conditions anticipated are for forage in the Great Clay Belt. Exploiting the opportunities responsibly requires going beyond incremental adaptation. Large-scale transformational shifts in where and how things are grown will likely be necessary. Enabling such a change by understanding adaptive capacity, applying systems thinking to anticipate and correct institutional barriers to action will help Ontario's agriculture sector overall to prepare for and cope with the impacts of a changing climate.

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