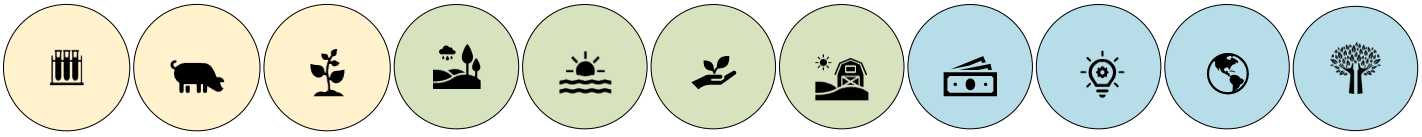
OMAFRA Priorities for the Ontario Agri-Food Innovation Alliance Research Program 2020-2021

Ontario Ministry of Agriculture, Food and Rural Affairs

October 2020



Ontario

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Introduction

Ontario Agri-Food Innovation Alliance

The Ontario Agri-Food Innovation Alliance (formerly the OMAFRA-UofG Partnership) is a collaboration between the Ontario Ministry of Agriculture, Food & Rural Affairs (OMAFRA) and the University of Guelph (UofG). Through the Alliance, OMAFRA and UofG work together to advance research and innovation that contributes to the success of the province's agri-food sector and promotes rural economic development.

On April 1, 2018, OMAFRA and UofG renewed the agreement governing the Alliance with a commitment of up to ten years. Alliance programming supports the intellectual capacity, infrastructure and networks that produce, synthesize, transfer and invest in world-class research, innovation, laboratory testing and veterinary capacity.

The Ministry's desired outcomes for the Agreement are:

1. Transparency and public confidence in the agri-food sector through the protection of public, animal and plant health, the environment, and Ontario's economy
2. The tools and ability to quickly and effectively respond to emergencies within its agri-food sector
3. An effective research and innovation system to achieve assurance in food safety, to protect animal, plant and public health and the environment, to grow Ontario's capacity to produce food, and to support a globally and domestically competitive agri-food sector
4. Development of future skilled capacity to be ready for employment opportunities offered by the agri-food sector and rural Ontario, including highly qualified veterinary capacity in place to meet Ontario's needs
5. Growth of third-party investment in agri-food and rural research, innovation and development, and data focused initiatives, and
6. Increased sharing and access to data to facilitate new agri-food and rural research and data analytics to inform government decision-making

The Research Program is a main component of the Ontario Agri-Food Innovation Alliance and provides funds for research projects that support the Agreement and the following strategic outcomes:

- Achieve assurance in food safety;
- Protect animal, plant and public health and the environment;
- Grow Ontario's capacity to produce food; and
- Support a globally and domestically competitive agri-food sector.

The University of Guelph administers the Alliance Research Program and makes recommendations on funding awards to OMAFRA.

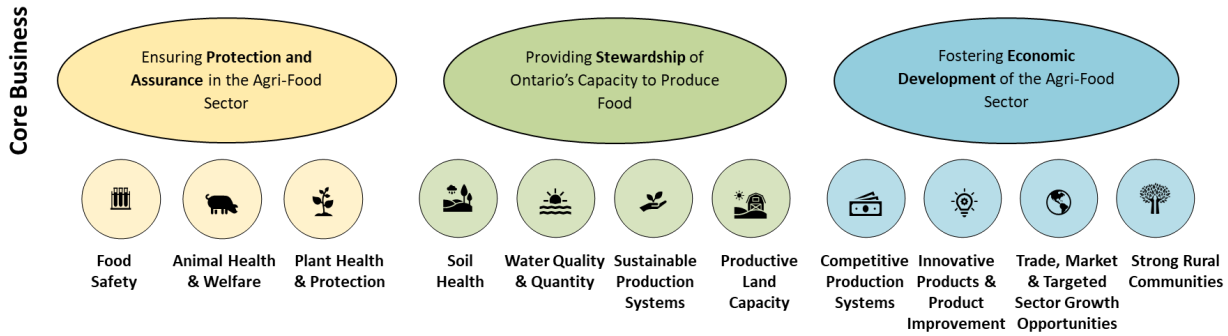
Full details on the Alliance agreement can be found here.

Overview: OMAFRA Research Priorities

The purpose of this document is to outline OMAFRA's research priorities that will be used to evaluate proposals received through the Alliance Research Program's 2020-2021 call for proposals.

OMAFRA is committed to, and has been working towards, the continuous improvement of its research programming, recognizing that research is an integral support to ministry core business areas, the sector and rural communities. As part of this process, in 2015 and 2016 the Ministry undertook a review of the research and information needs of government, clients and partners. More than 800 agri-food and rural stakeholders comprising farmers, food processors, rural communities and organizations, and commodity and farm organizations across the province were consulted. One of the key outcomes of that consultation was recognition of the critical role of the Agreement, and the need for the Ministry to enter into a renewed Agreement with UofG. In addition, OMAFRA undertook internal analysis and is implementing an enhanced and more flexible research priority-setting process to maximize research investments that support sector development and economic growth.

Improvements include a new ministry-wide, integrated approach to research priority setting that aligns research priorities with the Ministry's core businesses and objectives: Protection and Assurance, Stewardship and Economic Development. While many of the previous research themes remain relevant, they were established over ten years ago. The newly implemented research priority setting process has identified new research priorities that reflect the current needs of government and industry:



Each of these research priorities has a set of goals and research focus areas, in addition to five cross-cutting focus areas. Specific research questions for the 2020-21 Alliance Research Program together with the research problem/information gap and desired outcomes of the research are identified in the Appendix to this document.

Program applicants must clearly demonstrate that their proposal is within scope of OMAFRA's research priorities and fits with one or more of the research questions in the Appendix. **Proposals that involve the development of a product or service must include a Value Assessment Plan.** Additionally, six (6) specific research questions identified in the Appendix require a Value Assessment Plan.

PROTECTION AND ASSURANCE

Ensuring Protection and Assurance in the Agri-Food Sector

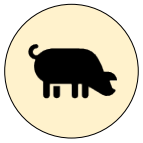
Food Safety

Goals

- Enhance public confidence in the sector to deliver on food safety, animal health, plant health, emergency management, and animal welfare expectations and demands.
- Anticipate, detect, mitigate and/or reduce food safety hazards along the supply chain.

Research Focus Area (refer to Appendix for detailed research questions)

1.1 Detection and surveillance: baseline data.



Animal Health & Welfare

Goals

- Enhance public confidence in the sector to deliver on food safety, animal health, plant health, emergency management, and animal welfare expectations and demands.
- Anticipate, detect, mitigate and/or reduce animal health hazards and antimicrobial use along the supply chain.

Research Focus Areas (refer to Appendix for detailed research questions)

2.1 Prevention and Control of Pathogens: Development and integration of effective prevention, mitigation and control methods for production limiting, new and emerging diseases and pest (e.g. antimicrobials or vaccines, biosecurity best management practices, carcass management).

2.2 Development of BMPs: Development of best management practices to improve farmed animal welfare (e.g. housing, equipment, pain management).

2.3 Health, Welfare and Productivity of Young Animals: Reducing morbidity and mortality in young, farmed animals.

2.4 Emerging Pathogens and Pests: Identification and understanding of new and emerging pathogens and pests in farmed animals.

2.5 Detection and Surveillance of Pathogens and Pests: New detection and surveillance methods/technologies to identify new and emerging pathogens and pests in farmed animals.

Plant Health & Protection

Goals

- Enhance public confidence in the sector to deliver on food safety, animal health, plant health, emergency management, and animal welfare expectations and demands.
- Help strengthen the agri-food sector's sustainability and social license through increased utilization of Integrated Pest Management and other pest mitigation strategies.
- Anticipate, detect, mitigate and/or reduce plant hazards along the supply chain, and improve plant resilience and resistance.

Research Focus Areas (refer to Appendix for detailed research questions)

3.1 Biology of Current and Emerging Pests: Understanding of the biology, climate resilience, ecology and management of current and emerging pests, and resistance management. Includes identification, tracking, monitoring, biosecurity practices and protocols, diagnostics and surveillance.

3.2 Pathway Analysis: Risks of new/expanding transmission pathways/distribution patterns of pathogens/pests.

3.3 Detection and Surveillance: Risk-based detection and surveillance methods/technologies.

3.4 Integrated Pest Management: Improved integrated pest management strategies through efficacy studies; alternative control options; development of management strategies.

STEWARDSHIP

Providing stewardship of Ontario's capacity to produce food

Soil Health

Goals

- Protect and enhance soil health and water quality, supporting improved public confidence in the sector to deliver on sustainability expectations.
- Improve soil health and conservation to support agricultural productivity.

Research Focus Areas (refer to Appendix for detailed research questions)

4.1 Environmental Impacts of Management Practices: Environmental impacts of fertilizer use, nutrient management and integrated pest management.

4.2 BMP Development: Develop, validate and continuously improve practices and technologies to support water quality and quantity, soil health, and sustainable agri-food production and processing systems (environmental, economic, social).

4.3 Baseline Soil Health Information: Baseline soil health information (i.e. relationship between physical, chemical and biological components) and development of robust and measurable soil health indicators.

Water Quality & Quantity

Goals

- Protect and enhance soil health and water quality, supporting improved public confidence in the sector to deliver on sustainability expectations.
- Strengthen the agri-food sector's sustainability and social licence through improved water use and water quality.

Research Focus Areas (refer to Appendix for detailed research questions)

5.1 Analysis of BMP Adoption: Understand the behavioural, social and economic barriers or incentives to BMP adoption by the agri-food sector.

5.2 BMP Development: Develop, validate and continuously improve practices and technologies to support water quality and quantity, soil health, and sustainable agri-food production and processing systems (environmental, economic, social).

Sustainable Production Systems

Goal

- Strengthen the sustainability of the agri-food sector through (1) Soil health and conservation, (2) Improved water quality (e.g. reduced phosphorus runoff and pesticides), (3) Increased water/waste/energy efficiency and reduced GHG emissions, and (4) Increased utilization of 4Rs Nutrient Stewardship.

Research Focus Areas (refer to Appendix for detailed research questions)

6.1 Analysis of BMP Adoption: Understand the behavioural, social and economic barriers or incentives to BMP adoption by the agri-food sector.

6.2 Environmental Impacts of Management Practices: Environmental impacts of fertilizer use, nutrient management and integrated pest management.

6.3 BMP Development: Develop, validate and continuously improve practices and technologies to support water quality and quantity, soil health, and sustainable agri-food production and processing systems (environmental, economic, social).

6.4 Impact of Changing Ecosystems on Ag: Understand the impact of changing ecosystems and biodiversity on agri-food production and processing systems to support an adaptive and resilient agri-food sector.

Productive Land Capacity

Goal

- Reduce the rate of loss of farmland through improved land use planning to support agricultural viability.

Research Focus Areas (refer to Appendix for detailed research questions)

7.1 Evidence to Support Land Use Policies: Evidence to inform land use policies to support policy and programs to protect farmland, support the viability of farmland operations and integrate land use with economic development.

ECONOMIC DEVELOPMENT

Fostering economic development of the agri-food sector and Rural Ontario

Competitive Production Systems

Goal

- Improve production efficiency, productivity, competitiveness and public trust efforts through technology adoption and innovation and technology development such a labour-saving technology or practices, automation, waste reduction, recycling, and increased water/waste/energy efficiency and reduced GHG emissions.

Research Focus Areas (refer to Appendix for detailed research questions)

8.1 Input Use Efficiency: Input use efficiency (e.g. alternative feeds, feed efficiency, automation in horticulture; irrigation efficiency in greenhouse, reproductive performance, food processing resource efficiency).

8.2 Improved Management and Processes: Improved management and processes (e.g. crop and livestock productions systems that improve yields and quality through agronomy, production practices, genetic methods, efficient fertilizer use).

8.3 Labour Access/Efficiencies: Research and evidence to support the development of strategies to ensure that the economic growth and sustainability of the agri-food sector is supported by adequate access to labour and/or labour efficiencies.

Innovative Products & Product Improvement

Goal

- Enhance competitiveness, profitability and growth of the agri-food sector through new or improved products.

Research Focus Areas (refer to Appendix for detailed research questions)

9.1 New Product Development: Investigate new products (physical products, services or processes) to improve marketability and profitability, meet consumer demands, and enhance productivity in the sector, from concept to prototype (e.g. alternative proteins, foods of the future, new crops, bioproducts).

9.2 Product Enhancement: Investigate means of enhancing products including: production conditions (e.g. plant establishment and survival in challenging environments); management practices; product trait development; new technology development and validation.

Trade, Market and Targeted Sector Growth Opportunities

Goals

- Growth of the overall agri-food sector through expansion of existing and access to new domestic and international markets.
- Improve economic performance of identified priority sub-sectors and increased production of niche and/or value-add products.

Research Focus Area (refer to Appendix for detailed research questions)

10.1 Targeted Sector Growth: Identify (in partnership with industry stakeholders), investigate and research opportunities to address targeted sector growth opportunities that will remove key barriers and improve competitiveness of the sector in the areas of: dairy goats, hazelnuts, aquaculture, greenhouse, maple syrup, processed vegetables, processed meats, baked goods and cannabis/hemp.

Strong Rural Communities

Goal

- Enhance competitiveness, profitability and growth of rural communities

Research Focus Area (refer to Appendix for detailed research questions)

11.1 Labour/Access Efficiencies**:** Research and evidence to support the development of strategies to ensure that the economic growth and sustainability of the agri-food sector is supported by adequate access to labour and/or labour efficiencies.

11.2 Rural Community Development: Research that strengthens municipal and agri-food sector capacity to identify and successfully implement provincial and other initiatives that are economically sound, environmentally sustainable and support rural community development.

Cross-Cutting Research Focus Areas for all Research Priorities **(refer to Appendix for detailed research questions)**

Please note: Questions for the cross-cutting focus areas appear throughout the Appendix.

12.1 Climate Change Resiliency: Understand risks and mitigation strategies to support an agriculture and food sector that is resilient and adaptive to climate change.

12.2 Technology Development: Identification verification, validation, demonstration and adoption of new, innovative and disruptive technologies and practices to support a resilient and sustainable agriculture and food sector.

12.3 Performance Measurement: Measure performance through baseline information, trend and gap analysis, impact assessment, and BMP adoption to quantify and benchmark performance.

12.4 Value Chain Analysis and Development.

12.5 Emergency Management.

OMAFRA Research Priority Contacts

Research Focus Area	OMAFRA Research Analyst
Food Safety	Susan Healey (Susan.healey@ontario.ca) 519-400-6361
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Plant Health & Protection	Anna Formusiak (anna.formusiak@ontario.ca) 519-400-7217
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Water Quality & Quantity	Rajib Hazarika (rajib.hazarika@ontario.ca) 519-400-9482
Sustainable Production Systems	Rajib Hazarika (rajib.hazarika@ontario.ca) 519-400-9482

APPENDIX: OMAFRA Research Questions

Please note: Question numbers link to Research Focus Area identifiers in the main document.

Question Number	Research Priority	Research Focus Area	Research Question	Research Problem or Information Gap	Desired Outcomes
FOOD SAFETY					
1.1.1	Food Safety	Detection and Surveillance: Baseline Data	What are the economic incentives/ drivers of food fraud in Ontario? What are the implications to the domestic and international market? What opportunities and innovative technologies are available for Ontario's agri-food sector to combat food fraud? What communication and knowledge transfer/ mobilization channels are available for the agri-food supply chain? How do we increase awareness of food fraud risks and influence behaviours to promote food integrity?	Food fraud impacts food safety, quality, brand value, public trust and emergency response. It is estimated that product counterfeiting globally is thought to be nearly 7 percent of world trade or over $600 billion. There is currently a gap in research on food fraud in Ontario. There is a need to better understand the food fraud drivers, innovative technologies and knowledge transfer networks among the agri-food sector, which will support the development of solutions and mitigation strategies to combat food fraud in Ontario.	The desired outcomes are to build evidence and understanding about food integrity and food fraud throughout the Ontario agri-food value chain. The results would assist government, industry and academia in identifying economic incentives, opportunities and communication channels to address food fraud risks and influence behaviours to promote food integrity. Outcomes of this research will strengthen the ministry's leading role in mitigating food fraud in response to the 2019 Auditor General's Value for Money Audit recommendations on food safety.
1.1.2	Food Safety	Detection and Surveillance: Baseline Data	What are the residual levels and data required to establish better usage guidelines and withdrawal times in livestock for drugs that have no current documented withdrawal period and no established maximum residual limit (MRL)?	OMAFRA tests for the presence of veterinary drugs in food animals. Some of these drugs do not have an established maximum residual limit (MRL) against which to evaluate the residue level found. Moreover, there is a gap in data which would allow CgFARAD (Canadian Global Food Animal Residue Avoidance Databank) to determine the appropriate withdrawal times (based on residue level/depletion rate) for drugs administered to livestock. Knowing what the depletion rate is for different drugs in different species would be valuable information, to help Health Canada determine MRLs, and help CgFARAD determine appropriate withdrawal times.	Project results will help to establish the risk level of certain drugs administered to livestock that enter the Ontario market. The results may be used to inform changes to regulatory policy as well as veterinary care best practices. This work would provide some field guidance to vets/producers.

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1.1.3	Food Safety	Detection and Surveillance: Baseline Data	What are the levels of viable but nonculturable (VBNC) cells (e.g. Listeria, crypto, giardia) in the wash water of flumes or dump tanks and their potential recovery on produce during postharvest storage?	The current reliance on culture methods to evaluate efficacy of wash water processes creates an information gap with respect to the presence of VBNC cells. These pathogens may be present but undetected, thereby posing a potential risk to food safety if they can become viable at the postharvest storage stage.	Project results will help to establish the risk level (how long cells persist, if they are being picked up and if are, they are truly viable or not) of products that enter the Ontario market. The results may be used to inform changes to regulatory policy as well as industry best practices.
1.1.4	Food Safety	Detection and Surveillance: Baseline Data	What practical / feasible interventions at any point in the value chain are effective for reducing or mitigating pathogens on Ontario-produced minimally processed or ready-to-eat (RTE) fruits and vegetables?	Minimally processed or ready-to-eat fruits and vegetables become contaminated with pathogens and have been attributed to a number of recent outbreaks of foodborne illness. Although there is a considerable amount of research on effective interventions, their may be barriers to their adoption and implementation.	Project results would be used to promote effective risk management strategies that incorporate interventions to reduce or mitigate pathogen contamination and have a greater potential to be adopted and implemented. This will lead to a decrease in the number of reported cases of pathogens in food, the number of food recalls, and the incidence of food-related outbreaks and illnesses.
ANIMAL HEALTH AND WELFARE					
2.1.1	Animal Health & Welfare	Prevention and Control of Pathogens	Examine the effectiveness of pre and probiotics on fish health and as an alternative to conventional antibiotics used in aquaculture.	Antimicrobial resistancy to conventional antibiotics increases overtime and decreases effectiveness of the drugs. Pre/probiotics provide an alternative approach to antimicrobial usage which is starting to be explored in aquaculture. Antibiotic usage hurts the social license of the industry as the public advocates for "antibiotic-free" sources of meat. Guelph university has HQP specializing in this field.	Identify pre/probiotics which are effective at treating bacterial diseases and/or improving fish health.
2.1.2	Animal Health & Welfare	Prevention and Control of	Tools to help mitigate the increasing issue of anthelmenthic resistance in sheep, goats and cattle	The Identification or development of cost-effective management or treatment options that lead to	Research into new BMPs, including genetic evaluation of Canadian sheep breeds for parasite

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		Pathogens	and the impact of this resistance on animal performance, health and welfare	improved control of internal and external parasites is a BCRC Research Priority. Anthelmenthic resistance in both cattle and sheep is a growing issue for producers in Ontario, although a more significant issue for sheep/goat producers than cattle due to the current levels of anthelmenthic resistance in the provincial sheep flock and the small number of licensed anthelementic products available.	resistance using quantitative trait loci (QTL) in a marker-assisted selection scheme. Several studies have reported QTL associated with nematode resistance in sheep, (i.e. native Scottish sheep breeds). Research into parasite mitigation benefits of grazing cattle and sheep and the benefit of grazing sheep on chicory & narrow leaved plantain - (NZ evidence of benefit)
2.2.1	Animal Health & Welfare	Development of BMPs	Effective and Humane Euthanasia of livestock and Poultry, from daily culls to whole farm depopulation	Evaluation of new techniques for euthanizing livestock and poultry, looking at large scale depopulation either for disease or market issues or emergency	Determine best methods for euthanasia that will address animal health and welfare needs and improve Ontario's Emergency Response capability
2.2.2	Animal Health & Welfare	Development of BMPs	Improved housing environment for all poultry to benefit workers	Improve the housing and/or the environment that poultry are in to improve production and animal welfare and improve worker and bird health.	Identify and evaluate alternative housing environments that lead to improved animal welfare and improved health without creating negative effects for the birds or the workers while being cost effective and sustainable
2.2.3	Animal Health & Welfare	Development of BMPs	What tools and techniques can be used to drive behaviour changes throughout the farm to processing continuum that will support best practices for biosecurity and animal management within specific commodity sectors?	Increasing the adoption of best practices related to labour (e.g. following public health guidelines), biosecurity and animal management is extremely important to ensure human and animal health and welfare. It's important to determine and identify tools and techniques (education, policies, programs, legislation, etc.) that act as both barriers and incentives to the adoption of best practices and understand any associated economic and sustainability considerations.	Research will help provide an understanding of what motivates producers to adopt a best practice. The results would assist commodity associations and OMAFRA with modifying tech transfer approaches to get better uptake of best practices, which will reduce COVID-related impacts to farm businesses moving forward.
2.2.4	Animal Health	Development of	What are economically viable housing systems and	There are several challenges with animal disease	Outcomes will include knowledge regarding housing

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	& Welfare	BMPs	management practices, which align with market and consumer demands and meet animal health and welfare needs?	transfer, social interactions, mortality, environmental quality, management practices and labour efficiencies within different housing options. The diversity of housing systems brings this diversity of issues in need of addressing to develop BMPs for individual systems and management practices.	systems and management practices that support economical, sustainable and efficient production, as well as optimized animal health and welfare.
2.2.5	Animal Health & Welfare	Development of BMPs	Are there new technologies or management practices that can eliminate the need for or further alleviate and prevent the stress and pain of currently accepted practices/procedures? (i.e. Dehorning, castration, tail docking, teeth clipping, hoof trimming)	There are currently few options available to reduce pain or stress during certain management procedures (i.e. Dehorning, castration, tail docking, teeth clipping, hoof trimming) and these options often require significant labour and/or cost to a producer. More options are needed to reduce time and cost requirements while still ensuring pain/stress reduction.	New best practices associated with common animal procedures, or new technologies to reduce the need for these procedures.
2.2.6	Animal Health & Welfare	Development of BMPs	How can stress, pain and injuries be reduced during transportation, at livestock markets and at slaughter facilities?	Transportation, market and slaughter are crucial periods in animal production. Research is needed to better address sources of animal health and welfare concerns. Livestock codes of practice (transportation time) are in flux and need evidence to support their development.	Codes of practices are under development for some species; knowledge from research could be used to guide evidence-based decision making. Handling, tools and best practices are market and slaughter facilities will be improved to support animal health and welfare.
2.3.1	Animal Health & Welfare	Health, Welfare and productivity of Young Animals	How do we improve the survivability of young farmed animals?	A prominent concern from multiple livestock sectors continues to be concern for reducing risk of disease and mortality in young livestock (LRIC 2019 Priorities). Specific factors leading to disease and mortality are largely unknown for a number of species. Benchmarking number of losses and cause of losses is needed to determine best practices or development of treatments to mitigate.	Knowledge to support livestock sector to improve morbidity and mortality rates in those industries with specific concerns; new recommended management practices, disease prevalence rates to better inform producers, development of solutions or treatments for producers to adopt.

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2.4.2	Animal Health & Welfare	Emerging Pathogen and Pest Identification	How can feed infected with mycotoxins be utilized for livestock without impacting animal health or performance?	With changing weather, mycotoxins are an increasing concern for animal feed; industries continue to struggle with mycotoxin loads. Mycotoxin research has been identified as a high priority need by Ontario Pork.	Sectors that are predominantly grain fed will be provided with information and mechanisms to alleviate negative health and nutrition effects or concerns of feeding grain contaminated with mycotoxins.
2.4.3	Animal Health & Welfare	Emerging Pathogen and Pest Identification	How can the risk of new and expanding transmission and distribution pathways of pathogens and pests be identified (diagnosed), quantified and mitigated in a timely and cost-effective manner?	Results of this research will contribute to the ministry's leading role in prevention of, response to and recovery from agricultural related emergencies, help fulfill the Ministry's legislative responsibilities and fulfill commitments to our federal, provincial and industry partners in emergency management. Current gaps exist regarding zoonotic, tick borne and parasitic diseases that impact multiple species and humans. The growing change in climate also introduces new concerns.	Outcomes of research will support the ministry responding to agricultural emergencies; prevention and control of new and emerging risks to the agri-food sector
2.5.1	Animal Health & Welfare	Detection and Surveillance of Pathogens and Pests	What new detection and surveillance methods can be used to identify and quantify new and emerging pathogens and pests in a timely and cost-effective manner?	Results of this research will contribute to the ministry's leading role in prevention of, response to and recovery from agricultural related emergencies, help fulfill the Ministry's legislative responsibilities and fulfill commitments to our federal, provincial and industry partners in emergency management. Detection and surveillance research will help to facilitate timely response to changes in frequency and distribution of pests and pathogens.	Research outcomes will include new detection and surveillance methods, or technology needed to better identify and quantify new and emerging pathogens and pests in a timely and cost-effective manner.
2.5.2	Animal Health & Welfare	Detection and Surveillance of Pathogens and	What are the therapeutic tools and alternatives or management programs that will improve the prudent use of or reduce the need for pharmaceutical	There continues to be a requirement to shift practices to those that support protection and assurance of the agri-food sector while adopting	Alternative prebiotics, probiotics and vaccines, alternatives to pharmaceutical use, and management strategies that can reduce the need

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		Pests	interventions such as antimicrobials, anthelmintics or other treatments? What are the impacts of these alternatives on animal, public health, economic and environmental sustainability?	more prudent use of antimicrobials and medications in livestock agriculture/aquaculture. All sectors are looking for alternatives to antibiotics. There are also concerns highlighted by staff and industry (LRIC 2019 Priorities) regarding availability of pharmaceuticals for several species; i.e. small ruminants continue to face the issue of "off-label" use for most antimicrobials.	for use of these. Drug depletion and residue studies to validate timing and use concerns while ensuring food safety and animal health/welfare. Reduce off-label drug usage.
12.3.1	Animal Health & Welfare	Performance Measurement (cross-cutting)	What are the economic implications to agriculture as a result of a) the changing use patterns of pharmaceutical interventions and/or b) use of alternative treatment and/or prevention practices?	Limited use and alternative products or practices present a number of unknowns with regard to their impacts on economics of the sector that need to be understood.	Confidence in supporting initiatives to reduce treatments like antimicrobials or support for use of alternatives, due to outcomes that validate economic sustainability of industries that adopt new practices / products.
12.5.1	Animal Health & Welfare	Emergency Management (cross-cutting)	Evaluation of animal welfare and worker safety parameters of mass depopulation methods for livestock and poultry	Evaluation of animal welfare and worker safety parameters related to new techniques for euthanatizing livestock and poultry, looking at large scale depopulation either for disease or market issues or emergency management.	Determine best methods for euthanasia that will address animal health and welfare needs as well as worker safety and improve Ontario's Emergency Response capability
12.5.2	Animal Health & Welfare	Emergency Management (cross-cutting)	Beyond the on-farm burial regulations identified in O.Reg. 106/09 Section 10, how feasible is above ground burial (AGB) as a disposal option in Ontario? Can AGB be effective as a disposal option in Ontario for ASF? Can AGB be effective for disposal of all sizes of swine carcasses in Ontario (weaner pigs, growers or finishing hogs)? How long does decomposition take? Are there seasonal aspects to take into account in the Ontario context? Antibiotics – residual effects – can this method be used to eliminate (or reduce) the movement of antibiotics to the environment? What	The arrival of ASF in Ontario would result in a significant number of losses of animals and would require a number of disposal options, including low cost on farm solutions. Currently, regulations in the Disposal of Dead Farm Animals Act allows for small scale on farm burial pits (< 2500 kg per pit) and small compost piles of < 600 cubic meters and small-scale disposal vessels. Producers will need a low-cost large-scale disposal option such as an Above Ground Burial System, currently utilized in some US states and will need more information	Recommendations for an Above Ground Disposal System for swine producers in Ontario, including carcass management to ensure minimal amount of negative environmental impacts and analysis to determine if this system be utilized for diseased and non diseased carcasses. Tools to determine appropriate setbacks that would need to be met to ensure a system can be utilized on a particular farm. Cost benefit analysis for producers to implement this system on a per hog basis and how does it compare to other feasible options (on farm burial,

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			are the appropriate setbacks from sensitive features, including private and municipal wells, lot lines, neighbouring AGB sites, swales, bushes, water courses? Systematically tile drained farms – can rows be placed between tile runs? What are the effects of different soil types as a base and a cover? Maximum number of carcasses per acre/disposal site? How far apart for rows? Can this be used to deactivate ASF vector/other diseases vs healthy swine? Cost benefit with respect to compost and on farm burial?	as to the feasibility of such a system for Ontario conditions.	composting, disposal vessel). OMAFRA staff to be included as team members on this project – Dan Carlow and/or Trevor Robak.
12.5.3	Animal Health & Welfare	Emergency Management (cross-cutting)	How can we modify readily available containers (e.g. shipping containers, dump trucks, etc.) for modified atmospheric euthanasia of pigs (i.e. CO2 and/or N2 gassing)? What is required for successful modification? Does it meet all aspects of animal welfare, including loading/animal movement and humane euthanasia? How quickly can units be modified? What is the cost associated with the modification? What is expected animal throughput of each unit? How is worker safety addressed, including animal handling, gas and system safety? Cost benefit analysis of conversion, operation and container type.	Evaluation of material requirements, speed of adaptation, costs, animal welfare and worker safety parameters related to modifying existing containers (e.g. shipping containers, dump trucks) for large scale depopulation of swine related to emergency management (disease and/or market interruption)	Develop procedures for modifying readily available containers for the purpose of humane gas based (CO2 and/or N2) euthanasia of swine, including animal welfare and human safety procedures. Determine speed of conversion, throughput of the units and costs associated with conversion and running costs on a per pig basis. Cost analysis of different container options. OMAFRA staff to be included as team members on this project – Laura Eastwood, John van de Vegte and/or Steve Beadle
12.5.4	Animal Health & Welfare	Emergency Management (cross-cutting)	What opportunities and innovative technologies are available to reduce plastic use during deadstock disposal at landfills in Ontario. What innovative technologies or materials are available to replace Biobags (plastic truck liners) used for this purpose with more environmentally friendly and cost-effective options. What are the economic costs and benefits of	In the event of a large-scale animal disease situation a significant number of animals may require euthanasia and disposal which would exceed the province's rendering capacity, so landfills are one viable option for disposal. However, landfills that accept deadstock in Ontario require the use of a sealable plastic truck	An analysis of Ontario's current capacity to produce sealable plastic truck liners or a company that can be retooled to produce them. Recommendations for environmentally friendly options that are locally produced in multiple sizes to fit various truck models. OMAFRA staff to be included as team members on this project – Dan Carlow, James Dyck,

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			these opportunities?	liner for disposal of the animals. This ensures there is no leakage from the truck during transportation and provides a single disposal unit regardless of the number of animals within the bag. These bags, commonly made of plastics, are not produced locally (which was highlighted as a large gap during COVID-19 emergency response) and are expensive. In a time of need for mass carcass disposal such as an ASF outbreak, obtaining enough Biobags will be difficult and cost prohibitive due to reliance on other countries for production. In the case of an emergency, the province could potentially expect to use up to 1,000 units/week for the duration of the outbreak. In addition, research into the replacement of single-use plastics with alternate materials or methods is required as the federal government has plans to place a ban on single use plastics by 2021 due to environmental concerns. Proposals should consider made in Ontario, biodegradable, and cost-effective options for sealable disposal truck liners.	Vicki Hillborn and/or Trevor Robak.
PLANT HEALTH AND PROTECTION					
3.1.1	Plant Health & Protection	Biology of Current and Emerging Pests	How can better identification and efficient and effective risk-based detection and surveillance in new and emerging weeds (e.g. Palmer amaranth) improve grower management strategies?	New and emerging weeds are constantly appearing and better ways to identify and manage them before they become an issue are needed	Research outcomes will improve the identification, tracking, monitoring and management of new weed pests entering Ontario. For Palmer amaranth: Through targeted surveillance identify any areas where Palmer amaranth has

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					established in Ontario and develop control strategies to prevent spread.
3.1.2	Plant Health & Protection	Biology of Current and Emerging Pests	Can resistant Prunus varieties be used to manage disease and insect damage?	Black knot and bacterial spot are extremely difficult to control using sprays or cultural methods. Black knot has the potential to kill entire trees. We have only copper based products available for bacterial spot management and stone fruit are sensitive to copper so the cure may be as bad as the disease. There is potential to identify germplasm that is resistant or at least less susceptible to infection.	Develop Prunus varieties with reduced susceptibility to fungal and bacterial diseases.
3.1.3	Plant Health & Protection	Biology of Current and Emerging Pests	Development of corn hybrids and wheat & barley varieties that are resistant/tolerant to DON and more transparent information on DON risk of varieties/hybrids.	Currently there are no corn hybrids or wheat & barley varieties with full resistance to DON available to Ontario corn and wheat growers. Development of resistant hybrids and verities would give growers another tool to reduce their risk. It may also result in less dependency on fungicide applications which are not 100% effective. There is currently limited information on the DON risk of commercially available corn hybrids in Ontario.	Corn hybrids and wheat & barley varieties with resistance to DON that are commercially available for Ontario growers. As well as more transparent information on the DON risk of current commercially available corn hybrids.
3.2.1	Plant Health & Protection	Pathway Analysis	How can plant health biosecurity risks associated with distribution channels be mitigated?	Knowledge is required to better understand distribution channels, spatial separation of imports (or packing sheds) and local production.	Research outcomes would identify risk pathways and distribution channels and reduce the infection of plant pests.
3.3.1	Plant Health & Protection	Detection and Surveillance	What are new or more effective on-farm plant pest diagnostic techniques and tools for difficult-to-detect pests or pests that require early diagnosis and intervention?	Growers need faster diagnostic tools. There are several barriers to existing tools including cost analysis, confidentiality and the difficulty of interpreting results. Further, some growers resort to unnecessary preventive pesticide sprays for	Research outcomes will identify more easy, rapid, farm-level disease diagnostics and provide evidence to reduce prophylactic pesticide applications.

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				difficult to detect pests, which can disrupt biocontrol programs.	
3.3.2	Plant Health & Protection	Detection and Surveillance	Can new technologies such as qPCR-based spore trapping networks, LAMP-based in-field disease assays, and/or microclimate disease forecasting systems result in more efficient use of pesticides and a decrease in overall pesticide use in horticultural crops including apples, asparagus, berries, carrots, grapes, onions, potatoes, tender fruit or tomatoes?	New technologies to aid horticultural crops with scouting, identification and disease/insect forecasting have recently been developed. Many of these technologies have great potential to increase the effectiveness of our IPM programs and efficiency of pest control products. Before they can be utilized widely, we need to evaluate if they will work in the Ontario context and where they fit within our current IPM recommendations.	Research outcomes will include updated IPM recommendations which incorporate these new technologies.
3.4.1	Plant Health & Protection	Integrated Pest Management	What novel IPM strategies (e.g. monitoring programs, forecasting models, cultural controls, chemical and biological controls) can be developed for new and specialty crops (e.g. specialty fruit, specialty vegetables, specialty grains, tree nuts, industrial and biomass crops, culinary and medicinal herbs) with limited to no existing pest control options available?	Most of the new specialty crops being adopted by Ontario growers have few to no registered pest control products and there is limited to no information on other effective IPM strategies. Efficacy data is needed to support product registrations and effective alternative management methods such as cultural, mechanical and biological controls, must be identified. Key crops requiring this information include cannabis and industrial hemp, hazelnuts and other tree nuts, hops, haskap and other specialty fruit, ginseng, lavender, herbs, quinoa and specialty vegetables.	Cost-effective, integrated management strategies identified which increase yields and reduce COP for specialty crops in Ontario.
3.4.2	Plant Health & Protection	Integrated Pest Management	How can potato early dying (PED) and common scab of potato be managed in Ontario through pest control products, improved cropping systems, fumigants, bio fumigation or soil building strategies?	Common scab of potato and potato early dying (PED) are the two most devastating soil-borne diseases in Ontario. Common scab has perennially been listed as the top pathology priority for potato growers across Canada with no effective chemical	Research outcomes will identify Ontario management recommendations for potato soil-borne diseases.

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				solutions identified. PED is a complex of pathogens which also require a holistic management approach. Some cover crop research has been initiated in Eastern Canada but the management practices being looked at would not be relevant to Ontario production. Ontario specific management recommendations need to be identified to reduce the impact of these soil-borne diseases.	
3.4.3	Plant Health & Protection	Integrated Pest Management	Which Pythium spp. are common in Ontario carrot fields and what are the best management practices to control carrot Pythium diseases such as cavity spot, rusty root and damping off?	Carrot Pythium diseases are caused by a complex of Pythium species causing a range of symptoms from cavity spot to stunting/forking. Resistance to metalaxyl, the primary control product used has been documented in other carrot growing regions. Research is needed to identify Pythium species infecting carrots in Ontario, determine whether Pythium resistance to metyalaxyl is present in Ontario and identify new products that can control Pythium in carrots.	Research outcomes will identify crop protection products and management strategies.
3.4.4	Plant Health & Protection	Integrated Pest Management	What integrated pest management strategies can be developed to manage fungicide resistance in strawberries?	Resistance to key fungicides (Group 11) has been identified in strawberry anthracnose populations in Ontario. With the changes in available fungicides for anthracnose control due to re-evaluations, and growing concerns with resistance, new and alternative pest management practices are vital for the continued success and viability of the Ontario strawberry industry.	Research outcomes will include new pest management tools and recommendations for strawberry growers to manage anthracnose fruit rot, botrytis grey mould, and other diseases.
3.4.5	Plant Health & Protection	Integrated Pest Management	What non chemical options exist for protection of transplanted field tomatoes to protect from early season insect pests (CPB, wireworm)?	Due to a loss of chemical control options and in furrow applications, transplanted tomatoes are at an increased risk to early season pest damage	Research outcomes will include new pest management recommendations for transplanted field tomatoes that reduces reliance on chemical

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				causing significant yield losses to the processing tomato industry. Pest specific solutions and recommendations need to be developed in order to protect transplants at this vulnerable and critical stage.	controls.
3.4.6	Plant Health & Protection	Integrated Pest Management	How can we encourage breeding for varieties that are pest and disease resistant in the greenhouse sector?	Most other agricultural crops include the cultural control of breeding for disease/pest resistance as part of their standard IPM programs. Floriculture is woefully behind the times regarding this - plants are breed mostly for aesthetics and growing vigour. However, recent outbreaks of devastating pests (e.g. impatiens downy mildew) demonstrate disease/pest resistance can be incorporated while still satisfying consumer demands	Research will identify common ornamental plant species that suffer from common, recurring pests where there are few control options. Research programs will focus on producing more pest-tolerant plant varieties and include consumer insights.
3.4.7	Plant Health & Protection	Integrated Pest Management	What new biocontrol agents can be identified and developed for commercial production and sale throughout Canada from endemic sources? How can biocontrol strategies be better incorporated and utilized in greenhouse production for efficiency? Is it practical and economical for key biocontrol agents to be produced on-farm to reduce shipping needs and carbon footprint?	Current greenhouse IPM programs are largely about tweaking programs for effectiveness and to reduce costs, as crops have low profit margins. Rearing insects on-farm would reduce buying costs, freight, and reduce burdens of common natural enemy shortages for growers in peak seasons.	Research outcomes would identify novel biocontrol agents and techniques that can improve on farm efficiency. It also may identify biocontrol agents that are most easily reared by growers using supplies that can be obtained easily and include an economic analysis of inputs and labour. Rearing guides would be developed.
3.4.8	Plant Health & Protection	Integrated Pest Management	How do we increase our understanding of the causes and management of ginseng replant disease?	Ginseng replant disease prevents the production of ginseng on the same land twice due to severe disease in the second crop and growers are running out of suitable land. The primary cause of the disease is the soilborne fungus Ilyonectria mors-panacis, but it is unknown why it is so severe in the second crop. Alternative management	Successful production of ginseng on the same land twice in at least the most suitable sites.

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				options are needed to control the disease. At the same time, it is important to understand the causes of the disease so more targeted management options can be developed. It is also important to quantify the potential for replant disease on a given site so growers can determine which sites are suitable for replanting. Investigate forest soils to determine how and why forest ginseng populations, having broad age structure, survive sustainably on the same area.	
3.4.9	Plant Health & Protection	Integrated Pest Management	Improved understanding of western bean cutworm (WBC) activity, crop preference, crop phenology and action thresholds, spray timing and application methods in Ontario corn and dry edible beans.	WBC is a significant insect pest of corn and dry edible beans. The number of moths and geographic range they cover in Ontario increases each year and their habits in terms of where and when they choose to lay their eggs also seems to change each year. Very little research has been conducted on WBC in dry edible beans in Ontario, and they are very difficult to scout for in beans. Growers are applying insecticide to control WBC without clear evidence of the impact on yield or quality, or clear indicators on when to best apply insecticides. Improvements needed in understanding in season population dynamics, factors that influence infestation variability and prediction tool development (e.g. GDD models)	Prediction tools to help determine potential infestations and spray timings, comprehensive integrated management plan and action threshold information is made available to dry bean producers. Detailed studies on WBC in Ontario clarify the activities of WBC, the factors that impact their egg laying timing and location choices, the impact of WBC on dry bean quality and yield, and how to effectively manage WBC in corn and dry edible beans.
3.4.10	Plant Health & Protection	Integrated Pest Management	Development of oat varieties with resistance to crown rust.	Currently there are limited oat varieties with resistance to crown rust which is an important disease that has a significant impact on oat production in Ontario. While resistance does exist	Oat varieties with resistance to crown rust that are commercially available for Ontario growers.

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				in one or two varieties, the resistance is breaking down and soon producers will be left with few or no options. Development of resistant varieties would give growers another tool to reduce their risk. It may also result in less dependency on fungicide applications which are not 100% effective.	
3.4.11	Plant Health & Protection	Integrated Pest Management	How can robotic weeders be utilized as part of an integrated pest management program in horticulture production systems?	With the loss of several key pest management tools expected in 2021-2024, as well as, the increase in the development of resistant pests, Integrated Pest Management programs for Ontario horticulture crops will require re-assessment to determine where gaps may occur in crop protection.	Robotic weeders available to incorporate into horticulture production systems at reasonable costs.
3.4.12	Plant Health & Protection	Integrated Pest Management	Development of alternative strategies to manage aphids to replace the use of Admire systemic insecticide in head brassicas, specifically Brussels sprouts	Brussels sprouts is a long season crop that is susceptible to pests and pathogens for an extended period of time. Currently, chemical products for organic and conventional production are limited and the crop is often unmarketable due to aphid pressure in Ontario. Other countries are able to produce to the crop, likely due to the availability of chemicals that are no longer available for use in Canada	Less unmarketable crops, increased acreage and the use of pollinator friendly insecticides
3.4.13	Plant Health & Protection	Integrated Pest Management	Development of sustainable Integrated Pest Management (IPM) practices and resistance management including insecticide efficacy testing, using degree day predictive models, development of economic thresholds, mating disruption strategies for Delia maggot flies in bulb and brassica vegetables	Improved tools for pest management are required. For example, maggot fly management in Allium and Brassicas relies heavily on seed treatments, or on group 1B organophosphates, specifically chlorpyrifos insecticides which have been identified as a major surface water contaminant in	Increased yields, better management of pests and deceased cost to growers

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				some vegetable growing areas. The prospect of insecticide resistance and potential restrictions of use illustrate the importance of alternative management strategies for this insect.	
3.4.14	Plant Health & Protection	Integrated Pest Management	What integrated pest management strategies can be developed for horticultural and field crop production systems that incorporate pesticides, alternative control measures, hosts resistance and/or take a systems approach to controlling pests, disease and weeds?	Resistant weed species require new integrated management strategies due to the limitation of post emergent herbicide options within specific crops. Also identified as a top priority for GFO. The Ontario Weed Committee (OWC) has identified the following priority species: a. Waterhemp b. Canada fleabane c. Wild oats d. Crabgrass e. Palmer amaranth f. Redroot and green pigweed Spotted wing drosophila in berries and tender fruit and cyclamen mites in strawberries require new integrated management strategies due to the limited options for control and the challenging nature of these pests. Top priority for BGO.	Research outcomes will include knowledge regarding tillage and timing in crop cycle, use and type of biodegradable mulch, robotic weed pullers, planting densities, row width, fertilizer placement. Research outcomes for insect management will include new management tools and recommendations for SWD or cyclamen mites.
3.4.15	Plant Health & Protection	Integrated Pest Management	How can integrated pest management programs evolve to deal with the loss of key pest management tools including fungicides and insecticides on fruit, vegetable, ornamental and field crops?	With the loss of several key pest management tools in 2021-2024, Integrated Pest Management programs for some Ontario crops will require re-assessment to determine where gaps may occur in crop protection.	Research outcomes will identify new or alternative management tools for crop protection.
3.4.16	Plant Health & Protection	Integrated Pest Management	What research priorities (breeding, in-crop management, post-harvest remediation etc.), or	Need to prioritize efforts which will have the most meaningful impact on reducing the economic	Thorough economic impact research throughout the entire value chain (breeding, grower, processors,

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			management strategies (hybrid, fungicide etc.) provide the best return on investment for reducing the impacts of DON across the whole value chain?	impact of DON throughout the value chain.	livestock producers), estimated value of reducing DON impacts at various steps (breeding, in-crop management, post-harvest remediation) and likelihood of success of various strategies at these steps.
12.1.3	Plant Health & Protection	Climate Change Resiliency (cross-cutting)	Influence that climate change will have on increasing or decreasing risk to new and emerging pests and diseases and overall plant health due to expected additional stresses caused by climate change.	How will climate change influence pest and biocontrol dynamics. As cropping systems will shift to adapt to climate change (e.g. new crops grown, earlier planting season, shift in geographical area where certain crops are grown). How climate change will influence natural enemy/biocontrol agents that currently help to manage these pests and diseases	Being proactive instead of reactive to addressing key pests and diseases, enabling the ag sector to prepare for new challenges in advance and make preparations to lessen the impact that pests and diseases will have due to climate change.
12.2.9	Plant Health & Protection	Technology Development (cross-cutting)	Development of strategies to improve storage quality, longevity and percent marketable product for bulb vegetables (garlic, onion, shallots) using modified atmosphere or other storage techniques	Consumers are demanding local products in the supermarket past December, an extension of storage life using modified atmosphere may allow these crops to store until April or May.	Increased demand for domestic Alliums, less food waste, increased acreage
SOIL HEALTH					
4.1.1	Soil Health	Environmental Impacts of Management Practices	What are the economic costs and benefits of soil health in cropping and pasture production systems?	There has been a notable and recent historic shift from perennial to annual crops in Ontario. This is strongly correlated with decreased soil health metrics (i.e. decreased organic matter and aggregation, increased bulk densities, etc due to increased tillage and field traffic.).	A better understanding of the economics of soil degradation and the significance to the Ontario agriculture sector.
4.1.2	Soil Health	Environmental Impacts of Management Practices	Soil Compaction. How do we determine the actual economic and environmental impact of soil compaction? Are their methods and/or sensors that we can use to measure the on the go stress exerted	Everyone knows that soil compaction is happening as springs and falls become wetter and farm equipment continues to get larger, but we continue to be unable to measure either	By truly understanding the economic and environmental consequences of soil compaction with hard numbers, we can drive adoption of practices and technologies to reduce soil

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			by equipment rolling across a landscape and understand it for its immediate and longer-term effects both economically and environmentally?	economically on environmentally what the real impacts are. The constantly changing load and landscape as equipment moves across a field makes the assessment of this very difficult.	compaction which is known to have a profound effect on both factors although the actual numbers are elusive. Without having hard verifiable numbers on the cost of soil compaction, we will continue to struggle to get people to invest in the management and technologies to address it.
4.2.1	Soil Health	BMP Development	Since there is little to no research on high organic matter (muck) soil cover crop options, what are the cover crops that fit within a muck vegetable production system and increase soil health parameters while reducing soil-borne pathogens?	Muck soils present a unique challenge for incorporating cover crops into the system due to their intensive high-value crop rotations and short planting windows. High-value crop production also leads to very short rotations and a build up of soil-borne disease issues. Muck soil is also very susceptible to soil erosion and subsidence, making cover crops all the more important to preserve soil health and long-term sustainable production. No research on the suitability of cover crops for muck soils specifically has been done so there is great potential for increased grower adoption with customized recommendations.	Identify and develop appropriate cover crop BMPs for Ontario's muck vegetable production system.
4.3.1	Soil Health	Baseline Soil Health Information	How can producers assess soil health in different production systems? (e.g., Grain production vs. specialty crop production)	Crop producers want to improve soil health and want to know how to accurately measure their progress.	An analysis of how soil health differs in field crops, horticultural crops, and specialty crops and tangible ways to assess soil health, either through soil tests, or combined with some other methods.
4.3.2	Soil Health	Baseline Soil Health Information	What are the best and most cost-effective biological measures of soil health?	Biology is a critical part of soil health, but current measures are limited due to knowledge and cost limitations. A review of existing biological indicators of soil health would help to refine our recommended measures in a way that is supported by science and minimizes cost.	Research will inform development of commercial biological soil tests that will ultimately provide producers and agronomists with information that can support management decisions for improved soil health.

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4.3.3	Soil Health	Baseline Soil Health Information	How do we develop a comprehensive understanding of what factors are needed to develop soil health tests that are accurate, cost effective, manageable?	There remains a lot of uncertainty on what constitutes an effective and practical soil health test that gives producers and their advisors confidence and manageable ability to conduct them that will properly steer better management in an economically feasible way.	Increased confidence in an economically viable soil health test would speed adoption of the methods and lead to more rapid improvement in soil health, thus reducing environmental impacts of crop production and enhancing economic performance.
WATER QUALITY AND QUANTITY					
5.1.1	Water Quality and Quantity	Analysis of BMP Adoption	What are the most cost-effective management practices for producers to reduce phosphorus losses in different production systems?	OMAFRA promotes a number of best management practices and this research would examine the costs to producers and the expected environmental benefits. This is a large undertaking, so the research could be designed to examine only the most practical and popular best management practices.	A ranked and costed comparison of management practices for producers to reduce phosphorus losses.
5.2.1	Water Quality and Quantity	BMP Development	Considering synthesis research on buffer strips (e.g. by Zhang et al. (2009) and Kieta et al. (2018)) how can riparian buffers be designed and managed to achieve better environmental results? How effective are new saturated buffer designs in trapping and reducing nutrient losses to surface waters?	Buffers are multifunctional yet are being dismissed as ineffective because they do not mitigate phosphorus loading unless properly designed to mitigate this issue	Research that provides evidence for or against the promotion of vegetated or woody riparian buffer strips as a best management practice for Ontario agricultural producers.
5.2.2	Water Quality and Quantity	BMP Development	Milking center washwater: What is the composition of milking centre washwater (e.g. total suspended solids, biological oxygen demand, nitrogen content, phosphorus content) for various types (i.e. cow, goat, parlour milking robot) and sizes of dairy operations in Ontario? What pre-treatment options would enable milking centre washwater to achieve "similar	Dairy farms generate washwater (milking center washwater) when cleaning the collection and storage tanks and piping used for milking. There is a disconnect between O.Reg. 267/03 under the Nutrient Management Act, and Ontario's Building Code (OBC), pertaining to	The desired outcome is a better understanding of the chemical composition of milking center washwater in varies types (i.e. cow, goat, parlour, milking robot) and sizes of dairy operations in Ontario and the necessary pre-treatments to make the material appropriate to be treated by an on-site sewage system at the farm. This work would

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			contaminant levels" to household (domestic) sewage and therefore enable disposal in an on-site sewage system as permitted by Ontario's Building Code? What are the costs of installation and maintenance of these treatment options by volume treated? How do these costs vary based on size of operation?	treatment and disposal of dairy milking centre washwater. O.Reg. 267/03 permits milking center washwater to be treated by means of a sediment tank and treatment trench system if the first rinse of washwater has been removed (clause 61.9). The first rinse tends to have high concentrations of contaminants which would interfere with a treatment trench system. OBC permits non-household wastewater to be treated in an on-site sewage system (including a sediment tank and treatment trench system) if the wastewater has similar contaminant levels to household (domestic) sewage. (Sentence 8.1.3.1.(3)). The OBC has an appendix note which states "…milking operations have wastes … are not suitable for discharge to an on-site sewage system."	support harmonizing the requirements of O.Reg. 267/03 and the Ontario Building Code, with respect to disposal of milking centre washwater, and economic assessment of any required treatment or disposal technologies.
12.1.7	Water Quality and Quantity	Climate Change Resiliency (cross-cutting)	How can we better assess climate change storm event driven nutrient loadings from agriculture?	We lack good data and evidence on non-point source nutrient loadings.	We need greater evidence to demonstrate that these large storm events are contributing to the majority of the loadings and if we can better deal with this on farm and in communities, we will improve environmental outcomes.
12.1.8	Water Quality and Quantity	Climate Change Resiliency (cross-cutting)	How can we better assess agricultural vulnerabilities (e.g. soil loss, nutrient loss, infrastructure damage) to climate change storm events and the response to associated adaptation strategies?	Evidence appears to indicate that our biggest problems occur in the 4-5 intense weather events that are happening on average each year and it would helpful to have decision-making tools to	Better risk assessment tools and adaptation strategies at the farm level to improve positive economic and environment farm outcomes and performance.

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				select the right strategy to avoid risk of increased environmental and economic loss/ impact.	
12.1.9	Water Quality and Quantity	Climate Change Resiliency (cross-cutting)	What are the potential pathways that pesticides may be transported to surface water and what are the potential impacts to aquatic life? What are some cost-effective mitigation measures/management practices that growers can adopt to reduce the movement of pesticides to surface water from the agricultural application area?	Neonicotinoid insecticides were found frequently in Ontario surface waters and are most agricultural uses are proposed for phase-out. It is important that we better understand the movement of pesticides from agricultural land to water sources and identify potential issues. If there are potential issues with movement of pesticides off of agricultural land, mitigation measures need to be investigated that will reduce risk to the environment.	Better understanding of the potential movement of pesticides and environmental impacts. This information can be used in the Pest Management Regulatory Agency's pesticide risk assessments. Ontario is taking a proactive approach to protect the aquatic environment and also help maintain/expand growers' pest management toolkit.
SUSTAINABLE PRODUCTION SYSTEMS					
6.1.1	Sustainable Production Systems	Analysis of BMP Adoption	What are the economic and environmental benefits, barriers and management options for incorporating more perennial crops in Southern Ontario? (i.e. forages, pastures, biomass crops, annual grasses): in corn and soy rotations?	Corn and soy production in southern Ontario is seen as limiting to improving soil health if other crops are not included in rotation. By examining evidence of barriers and options for including more crops in rotation, it may be possible to find ways to increase the practices. production of these crops. OMAFRA is seeking research to inform pasture management and forage production BMPs to support the diverse Ontario agricultural sector and foster greater competition with other jurisdictions.	A report directed at corn and soy producers that examines ways to incorporate more perennial crops in corn and soy rotations while maintaining or increasing profitability.
6.1.2	Sustainable Production Systems	Analysis of BMP Adoption	What are the strongest influencers that impact behavior change related to adoption of Best Management Practices?	What are the primary drivers behind decision making leading to behavior change?	the desired outcome is new knowledge of the key drivers to current behavior change decision making. Drivers could include (economics, values, peer

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					learning, labour saving)
6.2.1	Sustainable Production Systems	Environmental Impacts of Management Practices	How can Ontario reduce the amount of excess food going to waste? For example, finding ways to redistribute surplus product (processed or raw)	There are barriers that exist to increasing the amount of surplus, edible food that is prevented from being recovered in Ontario (including infrastructure gaps and social attitudes, such as misconceptions about perishability and stigma associated with recovered food).	Decreased amount of excess food going to landfill. Food recovery being further promoted and accepted as a means of reducing food waste in Ontario.
6.2.2	Sustainable Production Systems	Environmental Impacts of Management Practices	What are the costs and benefits of farming on marginal soil/land, e.g. is there a way to place a value on the role of wetlands in supporting agricultural operations and soil health?	There is a lack of data to support any conclusions about the cost benefit of crop farming on lands that are considered low yield potential (poor soil, former wetlands and low area etc.)	Better decision making by farmers and increased environmental benefit
6.2.3	Sustainable Production Systems	Environmental Impacts of Management Practices	How could climate change, biodiversity loss and land conversion affect the potential for new and emerging animal pathogens (including those which may have zoonotic potential), and how can those risks be mitigated?	Knowledge is required to better understand and interpret the impacts of climate change on animal production systems in order to mitigate negative impacts or adapt to changes without compromising animal health, welfare or production.	Research outcomes will inform producers and industry about issues to be aware of in order to take necessary steps mitigate.
6.2.4	Sustainable Production Systems	Environmental Impacts of Management Practices	How can economic benefits from cover crops (e.g. grazing, harvested as forage) be realized without compromising environmental benefits? i) Investigate various grazing/forage harvest strategies for cover crops and evaluate their profitability and impacts on environmental benefits ii) Determine site and/or operational characteristics that increase the probability of profitably utilizing cover crops while realizing environmental benefits	Cover crops provide long-term benefits to soil health and crop productivity, but short-term benefits are often not clearly apparent. Producers that rent land on short-term contracts represent a large and increasing acreage of Ontario farmlands. These producers are unlikely to implement cover crops; they would assume the costs, but unlikely to see the benefits. Research suggests there are opportunities to sustainably monetize cover crops within the year of implementation. Investigating these opportunities and providing guidance to producers would provide more incentive for	A report with recommendations on how to utilize cover crops (e.g. grazing strategies, forage harvest at certain conditions, etc.) so that economic and environmental benefits are realized. Report would consider operational and site-specific characteristics.

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				adoption and could lead to increased cover crop acreage.	
6.2.5	Sustainable Production Systems	Environmental Impacts of Management Practices	How can the environmental impact be improved for livestock sectors while maintaining productivity?	Knowledge is required to ensure that livestock operations reduce their environmental footprint in the greatest possible capacity. There is interest in also demonstrating the positive impact that some sectors may potentially have on the environment (i.e. In grazing sectors).	Research outcomes will identify methods for improving farm efficiency and best management practices that reduce environmental impacts while still meeting production goals and ensuring animal health and welfare.
6.2.6	Sustainable Production Systems	Environmental Impacts of Management Practices	Are there frameworks in other jurisdictions that Ontario should consider prioritizing stewardship actions on the landscape? (e.g. USDA Agricultural Conservation Planning Framework) How do OMAFRAs existing agri-environmental programming efforts map to these frameworks?	A number of tools exist or are in development relating to agri-environmental decision-making (EFP, Farmland Health Checkup, AgMaps, PLATO etc). How do these tools fit into a larger strategy for agri-environmental stewardship?	A jurisdictional assessment of frameworks for agri-environmental program targeting with specific focus on the USDA NRCS Agricultural Conservation Planning Framework.
6.3.1	Sustainable Production Systems	BMP Development	How do current Ontario crop fertility recommendations meet production advancements (new varieties, changed production practices for horticulture crops such as Potato, Ginseng, Asparagus, Hazelnut, new apple varieties)?	Other competitive jurisdictions (e.g. Quebec) have recently reviewed provincial crop recommendations. There is a need for Ontario to also review crop fertility recommendations to ensure both crop production and environmental stewardship goals are being addressed.	The desired outcome is that Ontario fertility recommendations reflect the current state of production advancement.
6.3.2	Sustainable Production Systems	BMP Development	How does nutrient stewardship practices (4R) apply to horticulture crop production?	4R research is critical for horticulture crops because these crops, especially annual horticulture crops, typically require higher soil test levels of phosphorus and potassium than oilseeds and grain crops for maximum economic production. There is a need f or Ontario research that supports and validates nitrogen, phosphorus or potassium	The outcome of this research will be new and/or updated nitrogen, phosphorus and potassium fertilizer guidelines for new and currently grown horticulture crops. The new and/or updated fertilizer guidelines would be approved by the Ontario soil Management

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				fertilizer guidelines for new and current horticulture crops in order to mitigate under- and over-fertilization, and related economic and environmental costs. Research is needed to improve crop nutrient use efficiency and minimize environmental losses (especially those crops in the Lake Erie watershed areas). There is also a need f or Ontario research that supports and validates best timing and placement of fertilizers for horticulture crops in general, and f or those destined for the certified organic market.	Research and Services Committee (OSMRSC) and included in OMAFRA crop production guides and updated in and/or added to AgriSuite. This would provide growers with fertilizer guidelines and reduce over applications of fertilizers.
6.3.3	Sustainable Production Systems	BMP Development	How do current non-stewardship programs affect adoption of new practices to benefit environmental sustainability objectives (e.g. soil health, decision to retire marginal farmland) and how can they be used to increase their contribution to sustainability objectives?	There is generally a lack of cross compliance between business support programs and linkage to environmental performance of the land as a stated requirement for participation in business programs.	Evidence to show the impact of BRM programs on the long-term investment tendencies of producers (e.g. does participation in BRM influence long-term investment tendencies related to building resiliency).
6.3.4	Sustainable Production Systems	BMP Development	What alternative protein sources can effectively be used in commercial salmonid diets to reduce the reliance on fish meal without negatively impacting fish health or meat quality?	Fishmeal comprises ~40% of most commercial salmonid diets and fish oils make-up another ~15%. Diets based on fishmeal are both expensive and bring into question sustainability of the industry. The aquaculture industry would benefit from salmonid diets based on alternative protein sources (e.g. insect larvae, black solider fly, algae, plant-based protein, yeasts, bacterial protein meal…) by reducing feed costs and improving the social license of the industry.	Identify alternative protein sources for salmonid feed diets which improve cost effectiveness, overall fish health performance, and decrease the need for fish meal as a primary protein source.

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6.3.5	Sustainable Production Systems	BMP Development	What is the baseline of cover crop adoption in Ontario? What are the costs and benefits of harvestable crops that provide soil cover? (wheat, rye, oats, other?) Which private sector partners are effective in increasing adoption of cover crops? What changes in the equipment industry are needed to increase the adoption of cover crops?	Continues to be an important practice for soil health and nutrient management. Specific focus in Agri-Environmental Plan Momentum in the sector but many questions about practical aspects of adoption	A clear understanding of the level of adoption of cover crops in Ontario, including regional differences and information gaps that hinder measuring progress.
6.3.6	Sustainable Production Systems	BMP Development	Agriculture and Environmental Regulation: What metrics can be used to evaluate the environmental benefit of current environmental regulation (e.g. Nutrient Management) in the agricultural sector in Ontario? How do these metrics compare with other jurisdictions? Would more/less stringent regulations produce a measurable improvement/impact to the environment? What are the economic costs and benefits to the agricultural sector of these regulations?	Increasing environmental regulations can have negative impacts on agricultural producers' productivity and ability to continue farming. Agriculture benefits from exemptions from strict environmental compliance requirements which other sectors are subject to (e.g. Environmental Compliance Approvals or ECAs). At the same time, much agricultural land is located in environmentally-sensitive areas (e.g. Lake Erie watershed, greenbelt, etc.) If agricultural operations are required to obtain ECAs (e.g. for manure spreading) this could significantly increase costs and impact productivity for farmers. Increasing environmental regulations pertaining to agriculture needs to be balanced with an understanding of the economic impact on the agri-food sector.	A cost-vs-benefit analysis of environmental regulations pertaining to agriculture. An assessment of how the desired environmental outcomes would be affected by increased/decreased regulations, and an economic analysis of those regulations.
6.3.7	Sustainable Production Systems	BMP Development	To what extend does net pen aquaculture impact the benthic invertebrate community below net pens? What is the assimilative capacity of benthic	Feed quota increases have been issued by the MNRF and will result in greater nutrient inputs at net pen sites over the next 10 years. The resulting	To accurately identify the assimilative capacity of benthic invertebrates in response to aquaculture inputs and utilize this informed knowledge to set

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			invertebrates in response to aquaculture inputs (feces, waste feed)?	effects on the benthos and sedimentation below net pens requires scientific investigation to better understand the relationship between nutrient inputs and the assimilative capacity of the benthic community. Greater understanding of this relationship will inform regulators to determine production levels which are ecologically sustainable.	sustainable production levels for net pen aquaculture.
6.4.1	Sustainable Production Systems	Impact of Changing Ecosystems on Ag	How can production efficiencies at the whole farm level be improved using crop and livestock management systems?	Producers often isolate production systems to make management decisions. Methods or strategies to evaluate the system at the whole farm level is needed to improve production efficiency and stewardship.	Research outcomes will identify methods for improving whole farm efficiency and best management practices that improve environmental stewardship on the farm.
12.1.4	Sustainable Production Systems	Climate Change Resiliency (cross-cutting)	What are the growth opportunities and challenges for domestic and export markets related to sustainability and/or other global market pressures (e.g. climate change impacts on global food supply security)? Have domestic or export markets changed in response to pandemic responses?	As the global demand for sustainably produced food, fibre and fuel increases and becomes a stronger driver of market access/competitiveness, there is a need to understand how Ontario's market development policies and programs can support the sector to take advantage of these emerging growth opportunities.	A report that provides a better understanding of Ontario's relative position to become global leaders in sustainably produced food and how this could influence Ontario's competitiveness both globally and domestically through differentiating its products.
12.1.5	Sustainable Production Systems	Climate Change Resiliency (cross-cutting)	What are the opportunities and barriers for Ontario to align economic recovery with sustainable growth? What Are the market trends with respect to use of sustainability standards in Ontario and other jurisdictions? How are agri-food companies and retailers responding to these trends, which standards are emerging as leaders, and what are the implications for policies and programs that could support Ontario's agriculture and agri-food sector to	As the global demand for sustainably produced food, fibre and fuel increases and becomes a stronger driver of market access/competitiveness, there is a need to understand how Ontario's market development policies and programs can support the sector to take advantage of these emerging growth opportunities.	A report that provides an understanding of market trends related to sustainability and the policy tools available to support the sector in retaining market access and taking advantage of new growth opportunities

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			become global leaders in sustainable products and production practices? Have domestic or export sustainability markets changed in response to pandemic responses?		
12.1.6	Sustainable Production Systems	Climate Change Resiliency (cross-cutting)	What are the environmental outcomes of perennial agriculture biomass crops and feedstocks (example outcomes Greenhouse Gases, decreased nutrient runoff)?	Links to Ontario environment plan and interest in addressing climate change.	Results of this research will contribute to ministry efforts in addressing environmental issues and reducing our greenhouse gas emissions foot print.
12.2.11	Sustainable Production Systems	Technology Development (cross-cutting)	Innovative growers, while often the spokespeople for new systems are also often at the "bleeding edge" of developing new crop and soil management systems; often making them ineligible for cost share or incentive programs. What is a fair way to support innovation?	Innovative producers often take all the risk in adapting a new process, especially in terms of the BMPs that have often been supported through incentive programs. They are often ineligible. How do other regions of the world deal with this? What is working? What would work here as a proof of concept?	This science need if met would support greater innovation on farm particularly in the area of BMPs for environmental benefit which in turn would support the positive influencing of the "moveable middle" and achieve more positive change in the landscape.
PRODUCTIVE LAND CAPACITY					
7.1.1	Productive Land Capacity	Evidence to Support Land Use Policies	How does Ontario's current policy framework help or hinder the integration of environmental stewardship and food security considerations into Agricultural System planning? What policies or policy changes are needed to incorporate food security and environmental stewardship objectives into Ontario's Agricultural System approach? How can emergency management response and risk mitigation be incorporated into Agricultural System planning to help the agri-food sector be more resilient with food supply/food security and environmental stewardship should future pandemics (or other disruptions) occur?	While we continue to promote and support implementation of the Agricultural System approach, we recognize that there is a need to integrate other key priorities such as environmental stewardship and food security. Integrating environmental and food security considerations into an agricultural system approach can help support a more resilient and sustainable agri-food sector (e.g. help support stewardship practices to adapt to climate impacts, social demands/interests).	1. Identification of current and potential future opportunities to integrate environmental stewardship and food security into the agricultural system approach. 2. Recognize the importance of incorporating other key priorities into the Agricultural System approach. 3. Increase uptake of on-farm environmental stewardship practices. 4. Identify opportunities to make land use planning

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				OMAFRA would benefit from expert academic research on this topic, from an external team comprised of land use planners, economists, food system planners, environmental specialists, etc. OMAFRA's traditional focus has been protection of farmland. This is no longer sufficient with increased environmental and economic challenges, and a sustainable approach is needed. The Agricultural System needs to be broadened to include food security and environmental stewardship considerations. While the Ministry does not oversee all determinants of food security (such as affordability and access), OMAFRA does influence farmland resource management, producer viability, capacity, safe food production, plant/animal health protection, trade and land availability. With increased potential for stressors on the food system and recent increased awareness of these risks (climate change, limited trade, labour, etc.) it is timely to understand how environmental stewardship and food security objectives can be more explicitly integrated into the Agricultural System approach. This research will help inform future policy development and implementation procedures for the Agricultural System.	more comprehensive by incorporating agri-environmental and food security considerations. 5. Demonstrate the role of farmland protection and stewardship to Ontario's food supply and the resilience of the Ontario's agri-food system.

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COMPETITIVE PRODUCTION SYSTEMS					
8.1.1	Competitive Production Systems	Input Use Efficiency	What are the best practices for in-crop application of nitrogen and phosphorus to reduce environmental losses and optimize nutrient use efficiency?	There is a lack of information on the effects of in-season nutrient (e.g. fertilizers, organic amendments) practices on N & P losses, N & P use efficiency and crop yields.	Best nutrient application recommendations for Ontario producers in order to reduce off target movement/losses (runoff, leaching, volatilization, greenhouse gases) and improve nutrient use efficiencies.
8.1.2	Competitive Production Systems	Input Use Efficiency	What is the best tillage (i.e. strip till) and nutrient (fertilizer and manure) placement combinations that optimize crop response and minimize environment losses? This applies primarily to phosphorus and nitrogen, but also to other essential nutrients (e.g. potassium and sulphur).	There is a need to provide more specific recommendations that balance the objectives of soil warming, drying and residue management (tillage) and water quality and crop response (P placement).	Required amounts of tillage and nutrients are optimized for crop production, and opportunities to reduce tillage are identified where it provides little benefit.
8.1.3	Competitive Production Systems	Input Use Efficiency	Can in-application testing of manure (for consistency, composition and nutrient value) be calibrated to provide uniform nutrient delivery to improve manure utilization?	Nutrient value of manure is often under estimated and over application of nutrients (manure and added commercial fertilizer) contributes to environmental losses and decreased nutrient use efficiency. Lack of awareness and/or confidence in existing technology contributes to this issue. Precision systems that include on-the-go analysis will help but require calibration to existing nutrient availability data.	Improved nutrient use efficiency and application uniformity from use of organic amendments so as to improve confidence in prediction of available nutrients. Where use of in-application manure testing is used, that available nutrients are calibrated with current Ontario research data.
8.1.4	Competitive Production Systems	Input Use Efficiency	What are the nutritional requirements of Whitefish? Are commercial salmonid diets nutritionally appropriate for the species?	Whitefish culture trials at the Alma Aquaculture Research Station indicate that standard commercial salmonid diets are not biologically appropriate for this species. Dissected fish exhibit excessive fat deposits in the intestinal lining indicating fat content of commercial diets are not appropriate. Little is known about the dietary	Understand the biological feed requirements of Whitefish and apply results to the formulation of a Whitefish specific commercial diet.

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				requirements of Whitefish in aquaculture. Industry has expressed interest in culturing this species but is limited by a lack of biological appropriate commercial feed for Whitefish.	
8.1.5	Competitive Production Systems	Input Use Efficiency	Food and Organic Waste: What are the opportunities and barriers for Ontario's agri-food sector to reduce and/or divert food and/or organic waste to create alternate products, generate revenue from and establish markets for/from these materials? What are the economic costs and benefits of these opportunities? Which waste sources are best suited for which revenue streams?	There is a gap of knowledge on how best to manage mixed organic waste streams (including food and organic waste) in a cost effective and/or profitable way. Options could include: converting culled fruit and vegetables to food products, including centralized de-packaging of food waste, solutions for rural municipalities, solutions for rural food processing businesses, achieving quality targets for contaminants, availability and cost of technologies, regulatory pathways, balance between feedstock volumes and end-use destinations. Potential materials include unsold crops (e.g. crop residuals, horticulture, nurseries and greenhouses), cheese whey and skim milk. Potential cost savings could come from finding more markets for imperfect produce or gleaning operations. Potential revenue sources including conversion into food products, nutraceuticals, nutritional supplements, Renewable Natural Gas (RNG) and use in anaerobic digesters, biochar, animal feed, and other new products.	To identify and validate innovative technologies and practices to reduce the volume of edible, but undesirable, products going to landfills. To satisfy objectives in the Made-in-Ontario Environment Plan on the reduction and diversion of food and organic waste from businesses. To inform Ministry policies supporting the development and expansion of the renewable natural gas (RNG) sector.
8.1.6	Competitive Production	Input Use Efficiency	What production practices and management recommendations can be developed to improve the	New knowledge and information is required for these new production	Research outcomes will include best management practices in producing strawberries and raspberries

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	Systems		yields, berry quality, season extension and competitiveness of strawberries and raspberries produced in soilless/substrate culture?	systems including research on protected culture, establishment, fertility and water requirements, harvesting methods and post harvest handling and storage in soilless berry production.	in a soilless system including fertility, irrigation, substrate choice, and protected culture.
8.1.7	Competitive Production Systems	Input Use Efficiency	How do we maximize the economic return of growing industrial hemp? What are the agronomic and production practices needed to optimize plant growth and productivity to take advantage of the entire plant and flower for CBD extraction? What are the processing technologies needed / available to harvest and process the crop efficiently and cost effectively to use the entire plant?	Cannabis/hemp is a new legal crop in Canada and the majority of cultivation licences are in Ontario. Outdoor production is expected to increase for cannabis and industrial hemp and CBD extraction poses a new economic opportunity for the industrial hemp sector. There is increasing interest in hemp from growers and industry on hemp for CBD, but production information is a major gap. Research is needed to understand the best way to cultivate hemp for CBC, to harvest CDB from large acreage hemp (processing) and the logistics of supplying to licensed processors.	To inform OMAFRA on production and processing practices to optimize new uses of this crop to enable KTT to growers and the sector. To support sector in leverage this new economic opportunity for which Ontario has a first mover advantage. UofG is developing capacity in cannabis/hemp research so this is an opportunity to leverage this capacity.
8.1.8	Competitive Production Systems	Input Use Efficiency	How can supplemental lighting be implemented in greenhouse production to improve plant quality, timing and costs in berries, cannabis, ornamental and vegetable crops? What impacts does supplemental lighting have on IPM and pest management in the greenhouse?	New knowledge is required for growers to identify the best lighting options for production and plant protection efficiencies and productivity. The solution should focus on improved management and yield year-round.	Research outcomes will include adoption of the most optimal lighting solutions.
8.2.1	Competitive Production Systems	Improved Management and Processes	What is the economic and operational viability of nanobubble technology in a recirculating aquaculture system?	Nanobubble technology has the potential to replace low head oxygenation (LHO) systems in RAS aquaculture. Reports indicate an oxygen transfer efficiency rate of 90% which is higher than the LHO efficiency rate of 70-80%. Additionally, the nanobubble technology requires less head to operate and oxygen retention is longer.	Determine whether nanobubble technology can reduce the operational cost of a RAS aquaculture by replacing LHO systems.

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				Nanobubble technology has been around for ~15 years but has not been widely adopted in RAS aquaculture. What is the economic viability of this technology when compared to LHO? What are oxygen transfer efficiency rates in production scenarios?	
8.2.2	Competitive Production Systems	Improved Management and Processes	What low-cost methods are available to treat irrigation water to reduce microbial contamination and meet Canadian Council of Ministers of the Environment (CCME) irrigation quality guidelines (0 - 100 E. coli/100mL depending on the water source and crop being produced) for Ontario horticulture crops? What are the economics of those treatment methods? What are the critical thresholds for plant pathogens (e.g. Pseudomonas spp., Botrytis cinerea, Fusarium spp., Phytophthora spp., Pythium spp., Rhizoctonia solani, Nematodes, Viruses) in irrigation water to avoid yield losses which cause economic impact to Ontario producers?	There is a lack of economic evaluations on the different types of water treatment options for different sizes of operations and sources of water. There is a lack of information on the thresholds at which different plant pathogens will impact the productivity and saleability of horticulture crops.	To increase the adoption of irrigation equipment within Ontario's horticulture crops to improve resiliency and quality of products. To help farmers adopt new treatment technologies for irrigation water to avoid the spread of pathogens both in food products and within crops. To inform the Ministry's cost share programs targeted to irrigation systems.
8.2.3	Competitive Production Systems	improved Management and Processes	Air Quality & ventilation in livestock barns: How does air quality (as measured by relative humidity, carbon dioxide, methane, ammonia and hydrogen sulphide) vary between different livestock types and housing styles? What are the best practices for designing ventilation systems for buildings housing livestock? What is the economic benefit of providing suitable air quality conditions on livestock productivity and the health of people working within buildings housing livestock?	Existing livestock barn ventilation systems are generally designed to manage only temperature and not other air quality requirements. Air quality in buildings can impact animal health and welfare, can reduce productivity and have a significant economic impact on the farmer. For example, high goat kid and dairy calf mortality rates caused by continued exposure to high relative humidity and ammonia adds cost in terms of medication, vet bills and replacement animals.	The desired outcome is to better understand the air quality within livestock barns, the impact of air quality on livestock productivity and to identify best practices for designing ventilation of buildings housing livestock.

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				In addition, barn electrical systems corroded through exposure to high relative humidity and corrosive gases (ammonia and hydrogen sulphide) is the leading ignition source for barn fires. Methane gas generated in under-floor liquid manure pits can serve as the fuel to increase barn fire size very quickly. The barn ventilation system that adequately manages these barn gases is a first line of defense in mitigating barn fire risk. Little to no research has been completed to understand the impact of barn air quality on the health of workers within these buildings.	
8.2.4	Competitive Production Systems	improved Management and Processes	Does the process of triploid induction on an Ontario stock rainbow trout improve growth performance under real life production environments and scenarios?	There is anecdotal evidence from industry that diploid rainbow trout outperform triploid fish in the net pen system but no evidence to support such claims. Industry grows both diploid and triploid fish without knowing which has overall greater yields (tonnage and value). Identifying which is optimal between diploid and triploid and switching production to match the outcome would result in increase production efficiency. A provincial breeding program benefits from this research as the program will have to decide whether or not to triploid their eggs and would want research to inform this decision.	This research will reveal whether a diploid or triploid rainbow trout is better suited for culture in a net pen system in Lake Huron.
8.2.5	Competitive Production Systems	improved Management and Processes	How can production and post-harvest information for new or emerging crops (e.g. industrial crops, specialty fruit, specialty vegetables, specialty grains, tree nuts, culinary and medicinal herbs, hops, biomass crops) be	Limited information may exist for new and specialty crop production in other jurisdictions, but this information needs to be evaluated and adapted for Ontario. Production information from	The development of agronomic information will allow Ontario growers to identify those specialty crops that represent the best diversification opportunities. Research outcomes will include best

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			evaluated and adapted for field production in Ontario (e.g. agronomy, cultivars suitable for commercial production, maximizing yield and quality under Ontario growing conditions, storage technology, packaging)	other jurisdictions may provide starting points but may not be applicable to our growing conditions. New knowledge is required in propagation and establishment, fertility and water requirements, season extension, harvesting methods and post harvest handling and storage in new and speciality crops.	management practices in establishing new crops, pre and post harvest handling, fertility and water requirements.
8.2.6	Competitive Production Systems	improved Management and Processes	What are potential techniques to increase post harvest quality for tender fruit and fresh grape? (i.e. Optimal harvest timing, packing and cold chain management systems, and practices to increase quality and shelf life.)	Optimal harvest timing and post harvest research helps to increase fruit quality and shelf life of fruit.	To develop best management practices for harvesting and storing fruit, that will optimize fruit quality.
8.2.7	Competitive Production Systems	improved Management and Processes	Evaluating training systems, canopy management and rootstocks to improve production efficiency in tender fruit orchards and vineyards.	To investigate the potential of training systems, canopy management and rootstocks to improve production efficiency and fruit quality in orchards and vineyards.	Improve production efficiency in Ontario orchards and vineyards and reduce labour costs through high density plantings.
8.2.8	Competitive Production Systems	improved Management and Processes	How can Ontario livestock producers extend the grazing season through management techniques, alternative crops, and integrated crop/livestock systems?	Grazing is usually the lowest-cost way to feed ruminant livestock. Extending the grazing season earlier in the spring and later in the fall can reduce the need for stored forages and improve producers' profit margins.	BMPs to extend the grazing season through management techniques, alternative crops, and integrated crop/livestock systems.
8.2.9	Competitive Production Systems	improved Management and Processes	What are the optimal planting dates and production practices for winter canola in regions across Ontario?	Winter canola is not susceptible to swede midge (#1 threat to spring canola) and because of the earlier flowering it is less affected by hot temperatures. Winter canola is likely a viable crop in many regions of Ontario, and although it is not commonly grown there are high capacity end users in Ontario (ADM in Windsor and Bunge in Hamilton). Winter canola keeps soil covered in	Best management practices for winter canola in Ontario by region are clearly outlined and communicated to local growers. Greater adoption of the crop increases the acres of soil kept covered through winter, more diverse crops are grown in rotation. Herbicide modes of action and timing of use are diversified resulting in improved control of herbicide- resistant and hard to control weeds.

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				winter, is a resource for pollinators in early spring, is highly competitive with weeds, and has high yield potential. Acreage could be increased across the province with data on appropriate planting dates by region, improved canola management recommendations, and potentially having more products registered for use in canola (plant growth regulators). More profitable options for keeping soil covered in winter and lengthening rotations would have value for Ontario soil health and sustainability.	Producers realize greater profitability with a high yielding crop. With greater adoption of winter canola, more varieties will be registered in Ontario (we have 1 hybrid variety available).
8.2.10	Competitive Production Systems	improved Management and Processes	How does barley and malting barley respond to intensive management practices under Ontario growing conditions?	Cereals provide significant value to crop rotations in Ontario field crop production. However, growers often opt not to grow barley or oats due to the lack of profitability compared to corn and soybeans and even winter wheat. Research is needed to get a better understanding of the intensive management practices (i.e. increase nitrogen, plant population, fungicide applications, plant growth regulators, etc). that barley and malt barley is most responsive to under Ontario growing conditions in order to improve profitability and ultimately encourage more diverse rotations that include spring cereals.	A comprehensive barley and malting barley management guide is available for Ontario field crop producers, resulting in improved yields, more diverse rotations and increased profitability
8.2.11	Competitive Production Systems	improved Management and Processes	New breeding efforts in grain crops to develop new competitive varieties in value added and identity preserved markets.	Availabilities of such specialized varieties opens access to higher value markets for Ontario grains.	Farmers are able to access higher value markets to enhance the overall ROI of grain production.
8.2.12	Competitive Production	Improved Management and	Examine reproductive performance of goats for breeding out of season and with artificial	Benchmark the current reproductive performance of goats in Ontario. Evaluate current strategies	Determine the best methods for consistent reproductive performance of goats on dairy goat

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	Systems	Processes	insemination.	used on farm for breeding goats out of seasons and by artificial insemination. This will help assess uptake of BMP for improved goat performance.	farms in Ontario.
8.2.13	Competitive Production Systems	Improved Management and Processes	How can Ontario increase the diversity of crops grown year-round efficiently and profitably?	The COVID-19 pandemic exposed several vulnerabilities in Ontario's food supply including heavy reliance on imports and production of a narrow range of vegetables year-round. Peppers, cucumbers and tomatoes are the primary vegetables grown in Ontario greenhouses. Some strawberries, eggplants and lettuces are greenhouse grown in smaller quantities. COVID revealed the opportunity and need for increasing the diversity of crops grown in greenhouses year-round to contribute to local and export markets and support Ontario and Canada's food security.	Diversity of crops grown year-round in Ontario.
8.3.1	Competitive Production Systems	Labour Access/Efficiencies	Automation in the horticulture sector: How can automation systems address labour needs in horticulture production and processing (e.g. mushrooms, apples, tender fruit, greenhouse vegetables)? What barriers are preventing adoption and how can these barriers be reduced?	High labour costs and availability of labour in all horticulture crops has become a challenge and the industry is looking for solutions and leaning on automation. Innovative technology is an important component that will help the agri-food sector increase its competitiveness and productivity. Automation and robotics adoption can also reduce critical labor shortages. It is therefore important to understand any barriers, perceived or otherwise, that negatively impact the adoption of this technology. In addition, it is beneficial to know the outcomes of adoption in automation & robotics, and whether the outcomes were positive, negative, or neutral.	A better understanding of the cost, benefits and barriers of using automation in the horticulture sector to reduce labour requirements.

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8.3.2	Competitive Production Systems	Labour Access/Efficiencies	Pandemic responses, availability of TFWs and possible accelerated increase of automated operations will increase the need for skilled and technical workers. Due to the increased role technology plays in agri-food, it is essential that the sector have an appropriately skilled workforce e.g. programmers, developers, data analysts, equipment technicians, and tech operators, to maximise technologies' potential to support the sector and increase productivity. Are these skills more in demand in certain sub-sectors and are they suitably prepared? If these skills are not available, what is the recommended approach for developing a workforce that has the required skillset? Are there any barriers/challenges for ensuring that the appropriate level of skill is available to utilize technology now and in the future?	Technology is playing an ever-increasing role in agri food. To ensure that its potential to help the sector is realised, Ontario must ensure it has an appropriately skilled workforce to take advantage of what technology can offer.	The desired outcomes include - identification of agri-food subsectors where skills may be more in demand, recommended approaches to ensuring a skilled workforce is in place and identification of barriers or challenges to developing this workforce. Results could inform policy and program development and design respectively, to help support the development and/or maintaining of an appropriately skilled workforce.
8.3.3	Competitive Production Systems	Labour Access/Efficiencies	As unmet labour demands increase, the need to understand new labour motivations increases. What attracts newcomers into the agri-food sector – what policy and programs exist that focus on recruiting, developing skills etc. How can programs and policies be improved, based on the stats of newcomers that enter the province with an ag. background who face barriers to working in ag?	Newcomers are a sector of the populace who could help with labour gaps in our sector. The ministry needs to understand what government levers (policies and programs) currently exist that supports newcomers working in the agri-food sector. In addition, it is important to understand how many newcomers come to Ontario seeking careers in agri-food, but face barriers to doing so.	The desired outcomes include understanding the current programs and supports in place to attract newcomers into the industry. Results could inform further policy and program development beyond OMAFRA, including MLTSD.
12.1.1	Competitive Production Systems	Climate Change Resiliency (cross-cutting)	What environmental strategies or new technologies can be used in greenhouse production to increase energy efficiency and reduce carbon emissions per unit produced (e.g. renewable energy, breeding for low light and temperature varieties, more insulated	Energy is one of the largest costs for growers, improving efficiency, adopting new energy models and generation ideas and being sustainable with non-renewable energy resources is a key priority for greenhouse producers.	Research outcomes will identify methods for improving greenhouse energy efficiency and best management practices that reduce carbon emissions while still meeting production goals.

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			greenhouse coverings, alternative energy models (e.g. peak shifting or microgrids) etc.?		
12.1.2	Competitive Production Systems	Climate Change Resiliency (cross-cutting)	How does including forages in row crop rotations affect the economic, agronomic and environmental impact of the whole cropping system?	Forages offer many soil health benefits and may play a key role in climate change mitigation. They also offer habitat for pollinators and other wildlife, promoting biodiversity in the rural landscape. Understanding how including forages in row crop rotations impacts crop production and the environment will inform Ontario's approach to soil health, climate change mitigation and agricultural production.	A literature review and analysis of the on-farm and landscape level impacts of including forages in row crop rotations on agronomic production and the environment. An economic analysis would be needed since there has to be markets for forages beyond owned livestock to get adoption of forages in a cash crop system.
12.2.2	Competitive Production Systems	Technology Development (cross-cutting)	What opportunities and innovative technologies are available to reduce, recycle, repurpose and/or replace plastic waste from the agri-food sector including farms, orchards, greenhouses, nurseries and food & beverage processing operations? What is the current state of plastics recovery in the agri-food sector? What are the economic costs and benefits of these opportunities? How could agricultural producers and processors be encouraged to reduce their reliance on single-use plastics, extend the life-cycle of plastics in use and increase recovery of used plastics? **Note: Proposals must include a Value Assessment Plan.**	In Canada, plastics recycling has typically been conducted at off-shore locations, but recent limitation on the shipping of plastic waste has resulted in an increased cost to dispose of plastics and increased demand for new ways to recycle plastics within Canada. The development of plastic recycling or reuse capacity within Ontario would address the plastic waste issue as well as create a new revenue stream from the sale of the recycled plastic feedstock. In addition, research into the replacement of single-use plastics with alternate materials or methods is required as the federal government has plans to place a ban on single use plastics by 2021. Potential areas of research include bioplastics, engineered fuel pellets, repurposing into alternative materials (e.g. bricks from used rockwool). Proposals must consider practical end-of-life options for	To identify new ways for Ontario's agri-food sector (including prime production and food and beverage businesses) to verify and adopt new and innovative technologies and practices to support the recycling, reuse or replacement of plastic products generated by the sector. To support the development of new and disruptive technologies and services (including a new service sector) to support a more sustainable agriculture and food sector by reducing the agri-food sector's reliance on petroleum-based plastics, including single-use plastics. To satisfy objectives in the Made-in-Ontario Environment Plan on recycling and reducing plastic waste.

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				alternative materials such as those described above.	
12.2.3	Competitive Production Systems	Technology Development (cross-cutting)	What are the options for mechanical harvesting of asparagus in Ontario?	Mechanical harvesting of asparagus has not been considered profitable in North America with access to an inexpensive source of labour. 2020's COVID-19 pandemic has demonstrated a labour-related vulnerability in the production of asparagus, a nutritious and emblematic crop for Ontario that yields approximately $30 million farm gate value from 3500 producing acres. Mechanical machines for asparagus of various designs exist, and an evaluation of asparagus harvesting technologies including testing/demoing both those in development, and those in use in other countries would aid the industry to develop a more secure harvest strategy.	A document to guide the import and/or production of mechanical asparagus harvesting equipment, to bolster the security of harvesting this commodity.
12.2.4	Competitive Production Systems	Technology Development (cross-cutting)	What technologies, mechanization or automation can be adapted to tender fruit, grape, apple and berry production to improve labour and operational efficiencies?	Berry, apple and tender fruit production are extremely labour intensive. The COVID-19 outbreak has made it very clear that tree fruit and berry growers need to look at options for reducing their reliance on manual labour. Improved processes and systems that reduce the impacts of and or costs of pruning, thinning (chemical thinners), harvesting and packing are needed. New technology including drones and robots are being developed to automate strawberry pest management & monitoring and harvest practices and they need to be tested for their applicability to production systems.	To identify, develop, and validate new technology that will contribute to labour reduction in berry, tender fruit and apple production. The development of strategies and practices that will reduce labour costs will be important for all three sectors. In berry crops specifically, UVC technology and robots for pest management, drones for monitoring and beneficial release, and robotic harvesters should be investigated. Outcomes include improvement in plant health and development of innovative products.

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12.2.5	Competitive Production Systems	Technology Development (cross-cutting)	What are the methods for establishing profitability mapping in order to allow for a systems approach to management decisions? How can profitability mapping be used to drive adoption of land retirement or reallocation within a given field to remove unprofitable areas from normal production?	The technology exists to carry out many precision agriculture practices but there is no real clarity on the science behind the practices or the return on investment of these tools and practices. Knowledge of site- / zone-specific profitability is crucial to farmer decision-making with regards to agronomic practices across a field. Adoption of BMPs by large segments of the farming population requires economic data that is best captured in a spatially-explicit format.	Clear advice to farmers on the elements of site-specific agronomy that provide a positive return on investment. Understanding of how site-specific factors (e.g. soil type) influence the results. More adoption of precision agriculture in crop production systems in order to identify and make management decisions that optimize economical and non-economical parts of the field.
12.2.7	Competitive Production Systems	Technology Development (cross-cutting)	What bio-based packaging options (such as compostable material) are feasible for Ontario food and beverage businesses that are cost effective, appealing to the consumer, and able to be accepted in common recycling or organics (e.g. green bin) collection programs and processed in typical Ontario processing systems (e.g. large-scale recycling or compost facilities and anaerobic digesters)? What innovative technologies can be applied to process alternative packaging options for use in the agricultural sector? Proposals must consider practical end-of-life options for the alternative packaging such as those described above. **Note: Proposals must include a Value Assessment Plan.**	Some food and beverage processors have started to introduce bio-based packaging alternatives as plastics recycling has become complicated, costly, and pose environmental challenges. Additionally, not all Ontario municipalities have the capacity to handle compostable and/or bio-degradable materials. Hence the reason practical end-of-life options are essential. Research into the replacement of single-use plastics with alternate materials or methods is required given the federal government's plan to ban single use plastics.	To identify new bio-based packaging options available to Ontario's food and beverage processors, that are cost effective, appealing to the consumer, and accepted in municipal recycling or organic collection programs. To support a more sustainable agriculture and food sector by reducing the sector's reliance on petroleum-based plastics, including single-use plastics. To satisfy objectives in the (draft) Made-in-Ontario Environment Plan on recycling and reducing plastic waste.
12.2.8	Competitive Production Systems	Technology Development (cross-cutting)	What automation or precision agriculture technology can be used to mitigate weather risks in apples/tender fruit and grapes, i.e. frost risk	Weather risks in apple production have been increasing due to climate change. Weather has become more erratic. We have been getting	Develop and validate new technology that can help predict and/or reduce weather risks such as frost, hail or heat stress/sunburn and winter injury.

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			prediction and protection, and hail risk prediction and protection	earlier spring-like temperatures which encourages buds to develop but our last frosts have not been moving earlier. We have been getting hotter temperatures in the summer which put our crops at risk of heat stress or sunburn. Polar vortexes in the winter have resulted winter injury in grapes and tender fruit crops.	
12.5.5	Competitive Production Systems	Emergency Management (cross-cutting)	Validate the vulnerability of the agri-food supply chain, such as the reliance of producers on a small number of packing and processing facilities for their crops and livestock, and the importance of effective management and storage practices and systems. What strategies and techniques can support food security through improved storage quality, longevity and increased marketability for crops and animal products?	The COVID-19 pandemic underscored the vulnerability of the agri-food supply chain, such as the reliance of producers on a small number of packing and processing facilities for their crops and livestock, and the importance of effective management and storage practices and systems. Evaluation of strategies and techniques to enable longer-term storage of agri-food products, especially highly-perishable fruits and vegetables, will enable increased marketability for Ontario's agri-food products.	Evaluation of strategies, techniques and technologies which can provide improved storage quality and longevity for Ontario agri-food products, resulting in increased demand for domestic foods, less food waste, increased acreage, and stronger emergency management strategies
12.5.6	Competitive Production Systems	Emergency Management (cross-cutting)	How can Ontario's institutional agri-food expertise (e.g. researchers, laboratory facilities, extension networks) be leveraged to rapidly respond to critical situations such as the COVID-19 pandemic? Which parts and partners in the agri-food supply chain can rapidly be repurposed/retooled to provide needed capacity to support public health and safety, supply chain resilience and rapid crisis management in Ontario? When inputs are diverted from the agri-food supply chain, what are the impacts, how can the supply chain respond and continue to operate?	The COVID-19 pandemic highlighted key weaknesses in scientific capacity in Ontario (e.g. shortages of laboratory facilities to analyze and process COVID tests). The agri-food supply chain and institutions (e.g. University of Guelph, OMAFRA, producer associations, laboratory companies) have significant expertise in disease management and mitigation (e.g. animal health researchers, zoonotic disease management tools) which can be leveraged more effectively to assist public health interventions and tracking of COVID-	Strategies to leverage expertise and capacity in the agri-food supply chain and institutions to provide rapid support to public health agencies and decision makers, while still providing needed support to maintain the agri-food supply chain and increase food security.

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				19 progress in Ontario. At the same time, the critical needs of the agri-food supply chain must continue to be protected and addressed, to ensure a stable food supply.	
12.5.7	Competitive Production Systems	Emergency Management (cross-cutting)	How can existing crop production systems be nimble and responsive in times of crisis to change crops and better maintain food security?	The COVID-19 pandemic exposed several areas in which Ontario's food production security could be improved. During the 2020 growing season there were ~1000 acres of non-food greenhouse production that could potentially be used for extended-season intensive food production, and there were reports of potential risks to ecosystem services such as wild pollinators, supply chain disruptions as well as labour and economic issues. This project seeks to develop strategies to increase food and economic security in Ontario by examining the potential for expedient conversion of production systems such as intensive food production in non-food greenhouses, and alternative crop rotation strategies that quickly maximize production, without increasing pest and disease risk, or harm to ecosystem services, as well as strategies to improve supply chain and labour resiliency.	A series of guidance documents will outline the challenges and opportunities for improving the resiliency of food production systems in times of crisis; for example, converting non-food greenhouses to food production, or altering crop rotations; and mitigation strategies for a range of weaknesses including labour, economics/cost of production, supply chain, and ecosystem services.
12.5.8	Competitive Production Systems	Emergency Management (cross-cutting)	The rapid rise of e-commerce resulting from shifting consumer preferences and demand for agri-food products (e.g. increased home cooking, reduced restaurant/food service demand, shift in meat consumption) and highlighted key supply chain weaknesses (e.g. retail vs wholesale distribution	The pandemic resulted in closures of many food service establishments and shifts to takeout/delivery only. Consumers moved to increased meals at home and home cooking, with reduced reliance on food service establishments. Products with high use in food service experienced	Analysis of pre- and post-pandemic shifts in consumer food preferences and demands. Strategies for increased flexibility and nimbleness in the agri-food supply chain to rapidly respond to changing consumer preferences and demands.

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			channels, bulk vs consumer packaging). How will consumer preferences continue to evolve post-pandemic? How can the agri-food supply chain become more resilient while also meeting consumer demand?	significant sharp decrease in demand (e.g. bacon, potatoes). Supply chain challenges prevented some products from being redirected to the consumer supply chain due to packaging and distribution limitations (e.g. bulk packaging not suitable/practical for retail). Consumer preferences for certain products in home cooking may be different than in food service establishments. Increased flexibility in the agri-food production system and distribution supply chains to rapidly respond to shifting consumer preferences and market demands more effectively will contribute to a stronger and more secure food supply.	
12.5.9	Competitive Production Systems	Emergency Management (cross-cutting)	Quantify the nature and extent of risks and weaknesses in the supply chain (e.g. integrated pest management options, crop protection products, animal health products/medication) and how can these risks be minimized to ensure availability of key inputs during unforeseen emergencies and supply chain disruptions (i.e. delays in accessing crop protection options)?	Recent emergencies (e.g. COVID-19 pandemic, CN Rail strike and blockades) have highlighted weaknesses in the supply chain and resulted in delays for producers accessing necessary inputs (e.g. medication shortages, delays accessing crop protection products, propane shortages due to rail stoppage). For example, most of the new specialty crops being adopted by Ontario growers have few to no registered pest control products and there is limited to no information on other effective IPM strategies, leaving growers with no options during supply chain shortages. To ensure a stable supply chain, the nature and extent of risks to disruptions needs to be understood across the agri-food sector, and mitigation strategies developed and	Analysis of the nature and extent of risks in the supply chain to disruption, and development of cost-effective strategies to minimize risks and ensure availability of key inputs during disruptions.

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				implemented to minimize impact of future supply chain issues.	
12.5.11	Competitive Production Systems	Emergency Management (cross-cutting)	Industry retention, recovery and resilience policy responses in other jurisdictions are expected to include additional investment attraction initiatives, potentially diverting investment from Ontario and/or impacting the competitiveness of the greenhouse sector. What incentives do competing jurisdictions offer for investment from the greenhouse sector? What impact is this having on the growth and competitiveness in the Ontario greenhouse sector (e.g. annual growth rates compared to areas like Michigan and Ohio)? What could Ontario do to improve the business climate and attract investment in the greenhouse sector?	There is currently a gap in knowledge in the business climate of competing jurisdictions that target investment from the greenhouse sector. Examples of incentives include tax abatement, low interest loans for infrastructure investments, utility rate relief, and long-term utility pricing contracts. Having an understanding of these incentives will inform economic development policy for the greenhouse sector in Ontario.	To fill gaps in knowledge of the greenhouse value chain, so that economic policy development enables business and investment attraction and for the sector to continue to compete in a global marketplace.
INNOVATIVE PRODUCTS AND PRODUCT IMPROVEMENTS					
9.1.1	Innovative Products & Product Improvements	New Product Development	What is the accuracy of the carbon sequestration values currently used for Ontario in the Holos GHG program, given these values were developed at a federal level in the absence of specific Ontario data?	OMAFRA is planning to release an updated AgriSuite software in the Fall 2019 which will include AAFC's Holos estimate of carbon sequestration through agricultural practices. Many assumed values used in Holos for Ontario will lack detailed Ontario-specific data. This evaluation will prioritize which numbers require immediate further research, or where new, improved values already exist and need to be incorporated into Holos or AgriSuite.	To support a more sustainable agricultural sector by validating new practices to reduce the greenhouse gas emissions from field crops and livestock. To satisfy the Made-in-Ontario Environment Plan's objectives for GHG reductions. To improve the accuracy of OMAFRA's GHG projections.
9.1.2	Innovative Products &	New Product Development	What new technologies could support Ontario's Greenhouse Sector and make it more efficient and	Greenhouse production is intensive, and often integrates tools and technology to make it more	Cost-effective technologies that improve labour, energy and production efficiency.

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	Product Improvements		sustainable? (e.g. Automation, sensor technology for climate and irrigation, packaging alternatives etc.) **Note: Proposals must include a Value Assessment Plan.**	efficient. Technology that can improve production, energy or labour efficiency is needed to keep the sector competitive in domestic and international markets. The sector is a strong adapter to emerging technology, and options for greenhouses of all crops and sizes continue to be in demand. Creating technology options in Ontario also has the added benefit of increasing the local support sector for Ontario growers.	
9.1.3	Innovative Products & Product Improvements	New Product Development	Are there new tender fruit and fresh grape varieties that can meet market needs? (e.g. higher value varieties suited to Ontario growing conditions and marketplace needs, an increase in organic production, fast tracking of virus free commercial production of promising varieties, disease resistance (fire blight, black knot and bacterial spot) **Note: Proposals must include a Value Assessment Plan.**	Tender fruit and grape growers need access to new cultivars that produce high quality, large sized fruit that meets the needs of consumers. These new varieties should be: - suitable for Ontario's climate - suitable for Ontario's post harvest handling (i.e. Not bruise on packing lines, ability to store without developing storage issues such as mealiness - disease tolerant /virus free (i.e. Black knot for plums, fire blight for pear, disease-tolerant wine grape varieties)	Tender fruit growers have access to fruit varieties that are tolerant of winter injury/ frost, helping growers to adapt to changing climate conditions. These varieties will also have traits that appeal to Ontario consumers, result in good yields, and fit well with packing lines, and have minimal issues with storage disorders (i.e. mealiness).
9.1.4	Innovative Products & Product Improvements	New Product Development	What agronomic/production practices and innovative technologies (e.g. biochemical, thermal, bioprocessing, nanotech, AI, blockchain) can be used for efficient processing of agriculture materials feedstocks with consistent quality and supply for the production of various bioproducts manufacture. **Note: Proposals must include a Value**	Over 42% of bioproducts establishments use agriculture biomass as a primary input. There is increasing consumer demand for bio-based sustainable products substituting fossil based, but limited agronomy research to drive development. Strong agriculture supply chains for bioproducts manufacture require consistent feedstock supplies. First generation biofuel industries in	Better understanding of production and post-harvesting practices and innovative processing technologies to meet quantity and quality demands by manufacturers of various bioproducts.

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			Assessment Plan.	Ontario and globally are transitioning to biorefineries for efficient utilization of feedstock inputs and co-products streams and for higher returns. Bio based feedstocks must also meet industry standards for the products they will be replacing. Ontario's advanced manufacturing strengths have the advantage for using biofibres, but many research gaps exist, and technology scale up is a challenge.	
9.2.1	Innovative Products & Product Improvements	Product Enhancement	What research is needed to facilitate the development of alternative crops to supply feedstocks (fibre, sugars, oils, chemicals etc.), to the bioproducts sector? **Note: Proposals must include a Value Assessment Plan.**	Development of a competitive and sustainable bioproducts sector will require the identification and production of needed feedstocks. Alternative uses of fibre from biomass or hemp are needed. Identification of non-traditional oilseed crops that replace petroleum products with renewable, carbon neutral feedstocks is also needed to combat climate change.	Use of agricultural waste materials and production of renewable, sustainable feedstocks for the bioproducts sector is important for reducing the impact of climate change.
TRADE, MARKET AND TARGETED SECTOR GROWTH OPPORTUNITIES					
10.1.1	Trade, Market & Targeted Sector Growth Opportunities	Targeted Sector Growth	Which global hubs (i.e. Dubai, Ethiopia, Singapore, Netherlands) present the best opportunities for Ontario's agri-food sector to seek realistic success in the next 2-5 years? Which subsectors of Ontario's agri-food sector might be most compatible with each market's needs? What are the potential barriers to overcome? How can these barriers be addressed?	Increasing exports is an important element of Ontario's trade agenda and can be accomplished through expanding presence in existing markets, through new regions and channels, as well as looking for opportunities in new markets, such as hubs. Government has a critical role to play in market development and diversification, as success requires long-term commitment from a relationship and logistical perspective. Not enough is currently known about the opportunities that	Obtain a better understanding of the challenges and growth opportunities for Ontario's agri-food sector in key global hubs to then potentially inform a strategic approach to guide key agri-food sectors to take actively pursue growth. Ultimately, this research would help answer the question if this avenue of market diversification should be a priority for OMAFRA.

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				Ontario could maximize in global hubs. Considering the significant volumes of travellers passing through hubs, extensive food service opportunities exist.	
10.1.3	Trade, Market & Targeted Sector Growth Opportunities	Targeted Sector Growth	What are the most promising economic end use market opportunities for biomass crops (switchgrass, miscanthus), hemp, crop & food processing residues and by-products and for potential industrial bioproducts manufacture and value chains best fits for Ontario	There is increasing interest in transition away from petroleum-based products and processes. The demand for increased plant-based products is expected to drive new economic opportunities for purpose grown feedstocks/biomass, organic residues/food wastes and other bio-based by-products. For example, Michelin plans to reduce its industrial carbon footprint by 50% by 2050 and Lego launched a range of plant-based plastic toys in 2018. Other companies/retail stores in the value chain, such as IKEA, Lego, Danone, Walmart, and Nestlé are incorporating policies for reducing fossil- based products and processes with those that are bio-based. There is potential use of biomass and hemp in buildings and construction industry. Understanding these new market opportunities from using biomass crops, hemp and agricultural feedstocks is important as information is lacking.	To support growth of the overall agri-food sector in Ontario. To enable expansion of acreage of biomass crops and hemp in Ontario and new market applications for biomass crops and hemp. For advanced materials and industrial bioproducts manufacture from biomass crop feedstocks and new feedstock supply chains and integrated bioproduct value chains which best fits for Ontario. Agriculture fibres use for materials and bioproducts manufacture can help for reducing the greenhouse gas emissions (GHG) substituting for fossil-based materials.
STRONG RURAL COMMUNITIES					
11.1.1	Strong Rural Communities	Labour Access/Efficiencies	The agricultural sector is a heavy user of manual labour. What specific strategies for training are most effective in developing and retaining highly skilled workers for the agri-food sector? What is the labour	Staff retention among domestic labour can be a real problem for the Ontario agri-food sector. Depending on the role, employees may be asked to preform specialized tasks including production,	Improve the skill level of Ontario agri-food workers and improve their longevity in specialized roles.

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			forecast for agri-food production and processing in the next 5-10 years? How can we shift from a sector that needs a great deal of general labour, to one that interacts and efficiently uses labour saving technologies?	pest management, management & HR, marketing etc. Retaining highly skilled personnel in production and pest management roles is especially needed for the sector. Owners also need to identify strategies to develop succession plans and leadership initiatives to keep HQP on their farms. The next generation of labourers will need to be able to manage improved technology and automation.	
11.2.1	Strong Rural Communities	Rural Community Development	To what extent do municipalities vary in their capacity to implement Ontario's provincial agricultural and rural land use policies; which policies are the most challenging for municipalities to implement; and what can be done to increase municipal capacity for more effective implementation? Municipal capacity to successfully implement crisis- related strategies/ action plans is likely to vary widely; identifying / understanding the reasons for different levels of capacity and risk will help to target provincial government support.	Recent updates to provincial policy in the Provincial Policy Statement, Greenbelt Plan and A Place to Grow: Growth Plan for the Greater Golden Horseshoe (2017-2020) and short timelines for municipalities to conform with these policies are putting significant demands on municipalities. Some municipalities (e.g. rural or urban-focused municipalities) may not have the staff or political expertise, time or budget to effectively implement provincial policies. Research is needed to help OMAFRA understand the extent of and reason for existing capacity challenges and how needs could be met to improve agricultural and rural policy outcomes. OMAFRA does not have the internal resources to lead this study despite its need and would not be	1. Understanding of the factors influencing municipal effectiveness at meeting and satisfying agricultural and rural provincial policies across Ontario on a timely basis. 2. Understanding of how frequently, and for which policies, municipalities find it challenging to address. Indicators of lack of capacity are generic or out-of-date official plans and zoning by-laws, appeals to the Local Planning Appeal Tribunal, and reliance on private sector consultants to undertake components of their land use planning (e.g. official plan updates, mapping or the completion of AIAs or MDS calculations). 3. Recommendations on best practices to improve municipal capacity to effectively meet, satisfy and implement provincial agricultural and rural policies (e.g. information, guidance, training, program funding, provincial staff support).

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				seen as a neutral party. A researcher is needed with a trusted relationship with municipalities across Ontario, particularly rural municipalities. In addition, ROMA should be involved to help to ensure rural municipalities are engaged and KTT is extensive. COVID-19 recovery depends on successful implementation of provincial agricultural and rural land use policies that may enable new agri-food opportunities and help address food security. Identifying / understanding municipal capacity challenges will help the province target methods that will be most effective.	
11.2.2	Strong Rural Communities	Rural Community Development	Stormwater management on farm and rural areas: What opportunities exist to collect and manage stormwater on-farm and in rural areas? How can this water be improved for quality and quantity management? What are the benefits and costs to using stormwater in agricultural applications (e.g. irrigation, livestock water) or rural applications (e.g. drinking water, firefighting)?	Farms and rural areas have potential to collect and store large amounts of stormwater, which could be repurposed for other uses (e.g. irrigation, firefighting, livestock watering, drinking water). There is a potential opportunity to utilize this water to improve water infrastructure delivery in rural areas.	A report that examines water use in a rural context and identified opportunities to use and reuse water more efficiently.
11.2.3	Strong Rural Communities	Rural Community Development	Cost benefit analysis of green infrastructure as an asset in rural and peri-urban water management systems. How would watershed management benefit from the incorporation of built green infrastructure as an asset within rural and peri-urban drainage infrastructure? What are the costs and benefits?	Although significant research has been done in the urban context in the U.S. and some limited research has occurred in Canada, much less is known about green infrastructure in the rural context. Green infrastructure is considered an emerging	Regionally-specific financial/economic analysis and case studies of rural and peri-urban drainage infrastructure that consider the impact of green infrastructure on agricultural productivity and flood protection. A clear business case is developed that identifies the costs and benefits of green infrastructure.

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				practice that is believed to have the potential to improve water quality, manage water to prevent flooding downstream, provide storage for times of drought, increase biodiversity, and maintain agricultural productivity. The sector requires an understanding of the costs and benefits associated with incorporating green infrastructure into Ontario's rural/agricultural drainage systems. Further, there is a knowledge gap on how the Drainage Act can be leveraged in urban settings to support green infrastructure.	In peri-urban, or non-farm contexts, this project would also assess the economic considerations for municipalities of utilizing the Drainage Act for implementing green infrastructure. The outcome would be research that that would inform decisions regarding the need for private and public investment and how any future policies and programs might be structured and implemented. An economic analysis is required to support commitments in the (draft) revised COA 2020 to promote eligible investments, including investments in green infrastructure, that support the reduction of excess nutrients from non-point sources such as urban and rural stormwater (including stormwater from agricultural landscapes), as priority considerations under applicable infrastructure and other funding programs as well as commitments to build infrastructure resiliency and avoid wetland loss in the Ontario Flooding Strategy 2020. Risk of not proceeding is failure to leverage green infrastructure funding for rural drainage and to support watershed scale flood management.
12.2.10	Strong Rural Communities	Technology Development (cross-cutting)	Many rural and remote municipalities are demonstrating leadership for bringing better connectivity for their residents and businesses. Unfortunately, many rural and remote communities have marginal business cases for broadband investments and as a result, it can be very difficult to secure private investment in these underserved areas.	Many rural areas of the province do not have access to broadband (high speed Internet) which puts them at a disadvantage vis a vis served areas of the province. This disadvantage impacts their economic prospects - where businesses do not have access to tools to take part in the 21st century digital economy, for example businesses	The desired outcome being sought are new ideas, new technologies or new processes that can be implemented to expedite the extension of broadband in rural Ontario.

APPENDIX: OMAFRA Research Questions

Please note: Question numbers link to Research Focus Area identifiers in the main document.

Question Number	Research Priority	Research Focus Area	Research Question	Research Problem or Information Gap	Desired Outcomes
			Municipalities are also prevented from investing directly in private telecom projects due to the bonusing provisions of the Municipal Act. Which existing tools (e.g. Community Improvement Plans for infrastructure developments), public-private joint ventures (e.g. through the establishment of a municipal holding corporation) and community partnership models could be used to assist municipalities working to deploy broadband in rural and remote areas? What new tools or municipal powers should be enhanced in order to facilitate more municipal leadership for broadband deployment in rural and remote areas?	can't take advantage of on-line sales platforms, on-line booking sites for accommodation, precision agriculture, apps, the ability to stream training videos, etc. As a result, this inhibits businesses and entrepreneurs from locating in rural areas and prevents those already in rural areas of maximizing their economic potential. In addition, the recent COVID-19 crisis has showcased the imperative for communities, residents and workers to have the ability to work from home, take part in education from home and be able to access government and health services digitally.	
12.5.12	Strong Rural Communities	Emergency Management (cross-cutting)	As part of emergency preparedness, rural communities have been facing many challenges, including financial challenges due to reduced revenue for businesses and municipalities, challenges in terms of the viability of local businesses and jobs, and challenges in terms of service delivery to vulnerable populations during a time of crisis. What vulnerabilities have been exposed for rural communities during such events? What can be done do to be better prepared for such emergencies in the future? What actions can be taken to address such vulnerabilities in the future?	Given the enhanced relevancy for emergency preparedness, rural communities have been grappling with many unforeseen challenges: Quarantining of residents, Continued delivery of critical services, Business closures, Temporary and permanent job losses, Loss of revenue for municipalities, World-wide public health and safety issues, Mental health, etc. Many communities found that they were not prepared for such an event, but they were able to adapt to this new reality and meet those challenges. Some communities fared better than others. During this process of adaption, however, rural communities are discovering areas of vulnerability of which they were not aware. Understanding how rural	Better understanding of the challenges faced by rural communities during the pandemic. Understanding what vulnerabilities were exposed due to this crisis. Identifying how communities can better prepare for future crises. Identifying actions that can be taken to address such vulnerabilities.

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				communities can better prepare for future crisis events will help inform emergency preparedness in terms of actions that communities and government can take. Understanding the vulnerabilities that have been exposed can help community leaders identify areas for improvement and readiness. This can also help inform how governments can better support rural communities in the future to ensure resiliency.	
12.5.13	Strong Rural Communities	Emergency Management (cross-cutting)	Rural communities often face challenges to economic growth, including regulatory and other barriers that prevent them from maximizing their potential.	Many rural communities face challenges and barriers to fostering and maintain economic growth. Moving forward, how can these hurdles be addressed, updated or modernized so that rural communities and businesses can thrive. Understanding these barriers, and what can be done to address them can help to enhance the quality of life for rural citizens, as well as, making it easier for businesses to create and retain jobs, and support economic growth in rural areas and regions across Ontario.	Better understanding of the challenges faced by rural communities and barriers to economic growth. Identifying how communities can adopt strategies to address these barriers. Identifying regulatory barriers where government has a role to play. Identifying actions that can be implemented to overcome these barriers and support economic growth