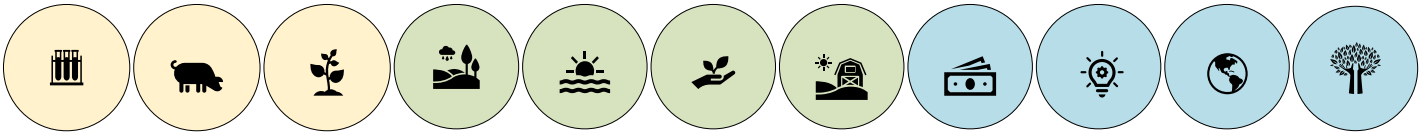
OMAFRA Priorities for the Ontario Agri-Food Innovation Alliance Research Program 2021-2022

Ontario Ministry of Agriculture, Food and Rural Affairs

August 2021

FINAL



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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 and Rural Affairs (OMAFRA) and the University of Guelph (UofG). Through the Alliance, OMAFRA and UofG work together to advance impactful research and innovation that contributes to the success of the province's agri-food sector and promotes rural economic development.

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 Alliance programming 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 respond to emergencies quickly and effectively 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.
6. Increased sharing and access to data to facilitate new agri-food and rural research and data analytics to inform government decision-making.

Beyond these overall outcomes for the Alliance, the ministry is also increasingly leveraging "One Health" principles to support a holistic and multi-disciplinary approach to protecting food safety, animal health and welfare, stewardship and protection objectives. The broader benefits of multi-disciplinary collaborations with a wider range of partners and governments is important for addressing persistent and complex challenges within the agri-food sector.

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

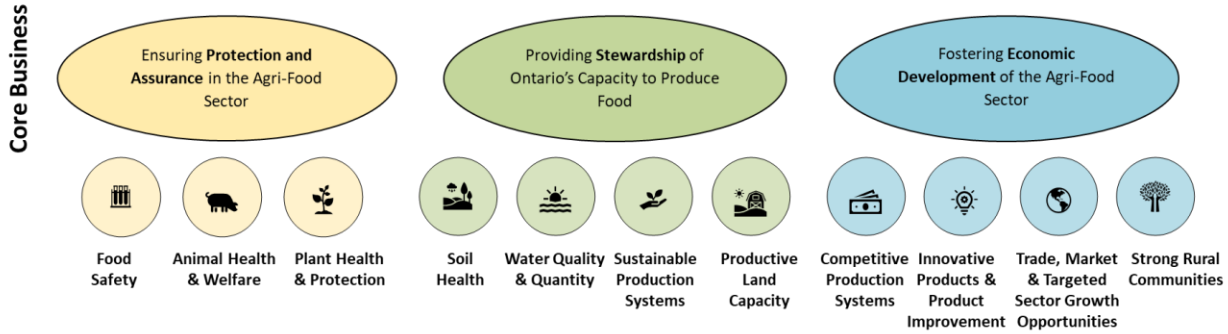
- Achieve assurance in food safety.
- Protect animal, plant and public health and the environment.
- Grow Ontario's capacity to produce food; and
- Support a globally and domestically competitive agri-food sector.

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

Full details on the Alliance agreement are available to the Ministry of Agriculture, Food and Rural Affairs, Ontario Agri-Food Innovation Alliance webpage.

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 2021-2022 call for proposals. Research priority setting aligns research priorities with the Ministry's core businesses and objectives: Protection and Assurance, Stewardship and Economic Development.



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 2021-22 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 (1)** of the research questions in the Appendix.

Proposals that involve the development of a product or service must include a Value Assessment Plan. Information about this will be included in the application. Additionally, fourteen (14) 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)

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

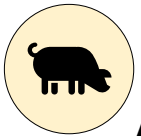
Detection and Surveillance: baseline data.

Innovative/Disruptive 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.

Performance Measurement: Measure performance through baseline information, trend and gap analysis, impact assessment, and best management practices (BMP) adoption to quantify and benchmark performance.

Prevention and Control: Verification and validation of prevention and control interventions

Validation of Detection Methods.



Animal Health and 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)

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

Emergency Management

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

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

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).

Plant Health and 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 (IPM) 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)

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.

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

Innovative/Disruptive 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.

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)

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.

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

Water Quality and 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)

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

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).

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

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 greenhouse gas (GHG) emissions, and (4) Increased utilization of 4Rs Nutrient Stewardship.

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

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

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).

Environmental Impact of Ag Production: Understand and quantify the impact of agricultural production systems on the environment (e.g. GHG emissions) to help mitigate

environmental impacts.

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

Innovative/Disruptive 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.

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)

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)

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).

Innovative/Disruptive 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.

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).

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.

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

Innovative Products and 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)

Innovative/Disruptive 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.

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).

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)

Domestic Market Analysis: Research, data and analysis to support Ontario's agri-food sector to remain competitive in domestic markets in response to change and challenges.

Global Market Analysis: Research, data and analysis to support Ontario's agri-food sector to remain competitive in global markets in response to change and challenges.

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)

Emergency Management

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.

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.

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

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.

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

Value Chain Analysis and Development.

Emergency Management.

OMAFRA Research Priority Contacts

OMAFRA Research Priority Contacts

Research Focus Area	OMAFRA Research Analyst
Food Safety	Hilary Graydon (Hilary.Graydon@ontario.ca) 519-546-8054
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Water Quality and 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

Food Safety

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Detection and Surveillance	**What is the pathogen burden in ready-to-eat (RTE) products from provincially licensed fish plants?**	With a new regulation for provincially licensed fish plants now in effect since January 2021, the Ministry requires baseline information, particularly on higher microbial risk RTE products.	Project results will help to establish the risk level of RTE fish products that enter the Ontario market. The results may be used to inform changes to regulatory policy as well as industry best practices.	2021.026
Detection and Surveillance	**What is the microbial load (e.g., Listeria, crypto, giardia) including viable but nonculturable (VBNC) cells in the wash water of flumes or dump tanks and their potential recovery on produce during postharvest storage?**	Wash water may lead to a higher risk of microbes on minimally processed produce than that of product directly from the field. In addition, 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.	2020.012
Detection and Surveillance	**What is the pathogen burden in ground meat products prepared in small-scale, provincially licensed facilities?**	Ground meat is particularly at risk for the spread of pathogens due to the comminution process and has been linked to several E. coli outbreaks. Small-scale facilities may not have the rigorous mitigation procedures that large scale and/or federally licensed facilities have to reduce this pathogen burden.	Project results will help provide needed data to establish the risk level of ground meat from small-scale, provincially licensed facilities.	2021.029

APPENDIX: OMAFRA Research Questions

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Detection and Surveillance	**What is the pathogen burden in market-ready lamb, sheep, goat and/or pork in Ontario?**	The lamb, sheep, goat and pork markets in Ontario are smaller than that of beef, therefore there is not as much information on the pathogen burden related to these markets. Research in this area will gather much needed data that will inform provincial operational protocols.	Project results will help establish the risk level of market products such as whole cuts and ground meats from these species, as well as help establish pathogen levels on the carcasses in slaughter plants.	2021.030
Innovative/Disruptive Technology Development	**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.	2019.055

APPENDIX: OMAFRA Research Questions

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Performance Measurement	**What innovative solutions and practical applications would be most effective to support behavioural change to increase adoption of food safety best practices along the value chain?** **For example, are there specific adult learning techniques (video, situational, experiential, etc.) that can be employed, and do they demonstrate improved adoption of food safety best management practices (BMPs) relative to the more traditional classroom / all-day online type of training.**	Inspections reveal lack of compliance with a range of mandated procedures in a wide variety of commodities; rates of voluntary adoption of BMPs (best management practices) are likely even lower. Examples include correct dehiding of carcasses (a critical factor in pathogen-free meat), appropriate use of pesticides on produce and appropriate microbial control in high risked produce such as minimally processed fruits and vegetables, microgreens and sprouts. The reasons for the low rate of adoption of some BMPS are not well understood but may include factors such as cost, lack of appropriate training tools/educational materials, etc.	Project results will help to identify innovative and practical solutions that will encourage the adoption of BMPs for enhanced food safety.	2020.010
Prevention and Control	**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, particularly for small scale producers and processors?**	Minimally processed or ready-to-eat fruits and vegetables become contaminated with pathogens and have been attributed to several recent outbreaks of foodborne illness. Although there is a considerable amount of research on effective interventions, there 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.	2019.061
Prevention and Control	**Foodborne human pathogens and toxins are moving into areas where they were not previously an issue due to a number of factors including changing weather. What are the food safety risks associated with this, and how can these risks be mitigated?**	Changing weather is facilitating the movement of some types of pathogens (e.g., fungi) to new areas, and the production of toxins (such as mycotoxins) in areas where they have not previously been observed. Understanding which pathogens/risks are of most concern, and in which crops/ foods/feed etc. is an important knowledge gap.	This research would identify economically important crops with the highest risks associated with changing weather, allowing for targeted interventions that would reduce economic losses to the agriculture and food sector, and to the provincial economy.	2020.009

APPENDIX: OMAFRA Research Questions

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Prevention and Control	**What are the potential food safety risks associated with relatively new vegetable production systems such as hydroponic and/or vertical farming and what intervention strategies can be used to mitigate these?**	Novel production systems such as vertical and hydroponic farming have been developed to produce sustainable food, while maximizing space. With the development of these techniques, it is important to evaluate the impact on food safety and determine the best way to mitigate any emerging risks, especially as we know that ready-to-eat and minimally processed produce have been linked to several foodborne outbreaks.	Project results will help to establish procedures to reduce pathogen load on vegetables grown using alternative production systems.	2021.027
Prevention and Control	**Along the value chain (from agricultural production to food processing) what are some lessons learned around food safety and security that can be put in action as part of a post-pandemic recovery strategy?**	Stress on the food supply chain post-pandemic is necessitating adaptation strategies from production to processing and distribution. Research in this area will help ensure that the lessons learned can be carried forward into ensuring a more resilient food system in the future.	Project results will provide information that could be used in a future crisis that has similar effects on the food supply chain.	2021.028

Animal Health and Welfare

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Development of BMPs	**What are economically viable housing systems and management practices, which align with market and consumer demands and meet animal health and welfare needs? Examples of identified species-specific research gaps in this area include the impact of flooring surface in housing and transfer areas on dairy goat hoof health and lameness, as well as need for poultry and swine.**	There are several challenges with animal disease 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.	Outcomes will include knowledge regarding housing systems and management practices that support economical, sustainable and efficient production, as well as optimized animal health and welfare.	2019.068
Development of BMPs	**Are there new technologies or management practices that can eliminate/reduce known painful conditions such as lameness and the need to 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.	2019.069
Development of BMPs	**How can stress, pain and injuries be reduced during transportation, at livestock markets and at slaughter facilities or other key handling points?**	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 for market and slaughter facilities will be improved to support animal health and welfare.	2019.070

APPENDIX: OMAFRA Research Questions

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
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 is also 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.	2019.075
Development of BMPs	**What new or emerging technologies or management practices can be utilized to ensure effective and humane euthanasia of livestock and poultry, from daily culls to whole farm depopulation.**	Foreign animals' diseases continue to pose a significant risk to livestock agriculture as evidenced by the recent global spread of African Swine Fever. Different jurisdictions continue to evaluate new practices for effective and humane euthanasia of animals. Evaluation of new technologies and/or techniques for euthanizing livestock and poultry domestically is needed, 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.	2020.014

APPENDIX: OMAFRA Research Questions

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Development of BMPs	**What are management methods and techniques that result in the production of sustainable, high quality (genetics and / or production) and high efficiency honeybees (queens and / or nucleus / colony production)?**	Ontario's honeybee economy lacks self-sustainability for locally produced queen bees, nucleus colonies and genetics. Queen breeding, production, viability and marketing in Ontario needs to be improved, which can help reduce producer reliability on bee imports.	Refined techniques for wintering, production and breeding of honeybees available to Ontario beekeepers. In the future this could result in: - More production and availability of honeybees in Ontario to beekeepers, and growers. - More bees exported to growers and beekeepers outside of Ontario.	2021.067

APPENDIX: OMAFRA Research Questions

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Emergency Management	**Improve preventative management practices and nutritional strategies to optimize rumen health and performance of feedlot cattle.**	According to the 2016 Canadian Beef Quality Audit, the incidence of liver abscesses detected at slaughter as part of the study has increased over the last number of years. The presence of liver abscesses is associated with suboptimal rumen health conditions. Development and adoption of management and nutritional strategies to address rumen health issues (outside of conventional antimicrobial control measures) are necessary to improving cattle health, welfare, and performance.	Identification of existing and novel approaches to mitigate rumen health issues in feedlot cattle	2021.007
Emerging Pathogens and Pests	**How can feed infected with mycotoxins be utilized for livestock without impacting animal health or performance? (Could include new testing technology.)**	With changing weather, mycotoxins are an increasing concern for animal feed; industries continue to struggle with mycotoxin loads.	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.	2019.072
Emerging Pathogens and Pests	**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.	2019.073

APPENDIX: OMAFRA Research Questions

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
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. 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.	2019.071
Health, Welfare and Productivity of Young Animals	**What tools are available to improve and evaluate colostrum quality to mitigate the increasing issue of lamb mortality?**	Sheep are dependent on colostrum to protect them in early life from pathogens because little immunity passes through the placenta. Little is known about what factors in the diet influence and can be used to improve sheep colostrum quality. Improved knowledge is also needed to accurately assess sheep colostrum quality as sheep colostrum is significantly different from goat or cow colostrum. Tools are urgently needed to reduce lamb loss to deliver on public expectations of animal welfare.	Recommended nutrition best management practices to improve colostrum quality in sheep producing multiple lambs. Producer tools to evaluate colostrum quality on farm. Improved colostrum quality in ewes with multiple lambs would result in a reduction in mortality of young lambs on Ontario farms.	2021.031

APPENDIX: OMAFRA Research Questions

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Prevention and Control of Pathogens	**What are the therapeutic tools and alternatives or management programs that will improve the prudent use of or reduce the need for pharmaceutical interventions such as antimicrobials, anthelmintic or other treatments? What are the impacts of these alternatives on animal, public health, economic and environmental sustainability?**	There continues to be a requirement to shift practices to those that support protection and assurance of the agri-food sector while adopting 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 regarding availability of pharmaceuticals for several species, i.e., small ruminants continue to face the issue of off-label use for most antimicrobials.	Alternative prebiotics, probiotics and vaccines, alternatives to pharmaceutical use, and management strategies that can reduce the need 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.	2019.067
Prevention and Control of Pathogens	**What practical tools are available to help mitigate the increasing issue of anthelminthic resistance in sheep, goats and cattle? What is the impact of these tools on animal performance, health and welfare? The focus of this priority is not livestock genetic improvement but may include crop management.**	The identification or development of cost-effective management or treatment options that lead to improved control of internal and external parasites is a sector research priority. Anthelminthic 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 anthelminthic resistance in the provincial sheep flock and the small number of licensed anthelmintic products available.	Research into parasite mitigation benefits of grazing cattle and sheep and the benefit of grazing sheep on chicory and narrow leaved plantain. Both crop species have high level of drought tolerance which permits the dual purpose of both drought resistance and parasite control. Increased drought resistance will help reduce producer dependence on RMPs, improve pasture sustainability and improve producer profitability through reduced reliance on stored forage.	2020.015

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Prevention and Control of Pathogens	**What is the effectiveness of alternative fish feed ingredients to improve fish health, disease resistance, productivity and sustainability of aquaculture feed ingredients?**	Commercial salmonid diets based on fishmeal are both expensive and bring into question sustainability of the industry. The aquaculture industry would benefit from salmonid diets which include a greater extent alternative protein sources (e.g., insect larvae, black solider fly, algae, plant-based protein, yeasts, bacterial protein meal). Pre/probiotics can improve fish health and productivity while providing 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.	Identify alternative protein sources for fish feed diets which improve cost effectiveness, overall fish health and productivity while decreasing the reliance on fish meal as a protein source. Identify pre/probiotics which are effective at treating bacterial diseases and/or improving fish health.	2020.085
Prevention and Control of Pathogens	**What are some options for low cost, in-field diagnostics for counting parasite eggs in feces?** **Note: Proposals must include a Value Assessment Plan.**	Research projects are underway to provide important selection tools to improve genetic resistance to parasites. These tools are dependent on sheep farmers collecting fecal egg counts from animals. The effectiveness of adoption is going to be dependent on cost and labour requirements of fecal egg count measurement. The current method used by laboratories is manual, time consuming, expensive and results aren't available when decisions need to be made on farm. A smartphone solution has recently been developed for horses.	A low cost, objective, diagnostic tool/technology that could be used on-farm by producers to estimate parasite load in individual animals. This would accelerate the adoption of tools currently being developed to select for parasite resistance in the Ontario sheep flock.	2021.008

Plant Health and Protection

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Biology of Current and Emerging Pests	**What is the biology and epidemiology for new and emerging pests (priority pests: Neopestalotiopsis spp on strawberry, Palmer amaranth, spotted lanternfly, Sudden Apple Decline, etc.) in Ontario or expanding pest ranges (priority pests: Japanese beetle, European apple sawfly)?**	Neopestalotiopsis is a new disease to Ontario and North America - one location in Ontario confirmed positive for this disease in 2020. Research is needed in Ontario. Palmer amaranth (Amaranthus palmeri) is a weed that has been spreading across the US. This plant has prolific seed production, grows rapidly, has prolonged emergence and competes very well with crops, leading to reduced yields. It has developed resistance in the US to eight different herbicide sites of action, including Groups 2, 3, 4, 5, 9, 1, 14 and 27. This leaves very few herbicide options available for management.	Research outcomes will improve the identification, tracking, monitoring and management of new/emerging/expanding pests in Ontario. Outcomes should include information on the spread and biology of pests, including in northern regions of Ontario.	2019.083
Biology of Current and Emerging Pests	**Research on more efficient risk analyses and - management of emerging pests that threaten the biosecurity of greenhouse, warehouse and vertical farms: How can disinfection and sanitation protocols (e.g., new technologies and/or processes) assist with this goal throughout the production cycle?**	New and emerging pests are constantly appearing and better ways to identify and manage them before they become an issue are needed. Risk management strategies to deal with emerging pests due to the effect of climate change and other factors are needed. The effects and impact of sanitation on improving biosecurity should be a part of these studies. For example, biosecurity in field can also impact nearby crops (i.e., cull piles impacting nearby crops)	Research outcomes will improve the identification, tracking, monitoring and management of new pests entering Ontario and protect the biosecurity of our greenhouse, warehouse and vertical, which also benefits field horticultural crops.	2020.064

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Biology of Current and Emerging Pests	**Are there commercial corn hybrids as well as wheat and barley varieties (either through development or identification) that are resistant and/or tolerant to DON (Deoxynivalenol) and more transparent information on DON risk of varieties/hybrids?**	Currently there are no corn hybrids or wheat and barley varieties with full resistance to DON available to Ontario corn and wheat growers. Development of resistant hybrids and 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. There is currently limited information on the DON risk of commercially available corn hybrids in Ontario.	Corn hybrids, wheat and 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.	2020.087
Biology of Current and Emerging Pests	**Is Soybean Cyst Nematode (SCN) causing economic damage in snap bean?**	Snap beans are a commercially important processing crop that have been suffering from yield reductions in some field areas. This is suspected to be due to Soybean Cyst Nematode (SCN). Preliminary work has demonstrated the presence of SCN in snap bean fields, but it is not known whether the yield reductions seen in practice are due to this pest, a disease complex involving this pest, or an external factor.	Research outcomes will include recommendations for control of SCN in snap beans, and future studies into snap bean susceptibility to SCN.	2021.044

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Biology of Current and Emerging Pests	**What mitigation strategies can be implemented for difficult diseases and disorders of apple, including apple replant disease complex, canker complex and Sudden Apple Decline (SAD).**	Apple replant disease, canker and SAD reduce tree vigour and yield. In the case of replant disease, growers are limited in suitable virgin land. All issues are a result of a complex of biotic (e.g., fungal, nematode, virus) and abiotic (e.g., weather, soil health, winter injury, water stress, cultivar/rootstock sensitivity) factors. Mitigation strategies are needed to prevent tree loss. At the same time, it is important to understand the causes of these complex issues 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.	Research outcomes would identify new tools and strategies to manage complex apple issues include replant disease, cankers and SAD.	2021.045
Biology of Current and Emerging Pests	**What are the mechanisms that lead to skin disorders of ginseng (e.g., rusty root) and how can they be mitigated?**	Ginseng is prone to many diseases and disorders that are difficult to diagnose and may be caused by a combination of biotic and abiotic factors. These disorders lead to significant reductions in root quality and marketability. There is a need to identify what factors lead to development of these disorders (weather conditions, rainfall, irrigation events, soil nutrient and pH status, and soil-borne pathogens) and determine how growers can reduce the incidence and severity of these issues.	Identification of the factors that lead to superficial skin disorders of ginseng. Development of procedures to mitigate the occurrence of these disorders.	2021.046

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Climate Change Resiliency	**How can more efficient risk analyses be implemented around the management of emerging pests that threaten outdoor horticulture and field crop farms? How can the resiliency of the sector be improved to better manage new invasive species resulting from shifting climate zones?**	New and emerging pests are constantly appearing and better ways to identify and manage them before they become an issue are needed. Risk management strategies to deal with emerging pests due to the effect of climate change and other factors are needed. Forecasting methods, predictive tools, economic thresholds are needed for various pests for Ontario specific conditions.	Research outcomes will improve the identification, tracking, monitoring and management of new pests entering Ontario and protect the biosecurity of our outdoor horticulture and field crops.	2020.102
Innovative/Disruptive Technology Development	**Can new technologies such as qPCR based spore trapping networks, LAMP-based on farm disease assays, and/or microclimate disease forecasting systems result in more efficient diagnosis of difficult-to-detect pests or pests, more efficient use of pesticides, rapid resistance testing and a decrease in overall pesticide use in horticultural and greenhouse crops including fruit, vegetables, ornamentals? What are the economics of these technologies?**	Growers need faster and more reliable diagnostic tools. New technologies to aid horticultural and greenhouse 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 integrated pest management (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. 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 difficult to detect pests, which can disrupt biocontrol programs. Important crops include but not limited to apples, asparagus, berries, carrots, grapes, tender fruit, potatoes, onions, tomatoes, ornamentals.	Research outcomes will identify easy, rapid, farm-level disease diagnostics which incorporate new technologies, update IPM recommendations, and provide evidence to reduce prophylactic pesticide applications.	2020.054

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Innovative/Disruptive Technology Development	**What are some 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.	2020.103
Innovative/Disruptive Technology Development	**What are some quick, efficient and economic treatment of surface irrigation water for plant pathogens? (Crops of interest: tomato, pepper, cucumber, ginseng, herbs, list crops)**	Irrigation water is a common pathway for damaging soil pathogens such as Phytophthora spp., Pythium spp. and Fusarium spp. to enter a crop and spread to uninfected fields. Infested water is used either through drip or overhead irrigation directly to the cropping system where pathogens infect plants causing losses in production.	The development of a system to treat surface irrigation water as it is pumped from the source to the crop. The system should be fast acting, have minimal effects on the crop itself and be economical to growers (ideally).	2021.047
Integrated Pest Management	**What are some integrated pest management (IPM) strategies for horticultural and field crops that take a systems approach to controlling important pests (insects, mites, diseases and priority weeds)? Examine tools for management and reporting /sharing of scouting data. Investigate policy and program tools which could be used to support the systems approach to controlling pests, diseases, and weeds.**	Integrated pest management solutions are needed in all cropping systems. Overreliance on few strategies to manage a pest, especially chemical, is unsustainable for any pest/crop. It is important to consistently look for new and improved solutions. Priority species of weeds include water hemp, Canada fleabane, wild oats, crabgrass, Palmer amaranth and pigweed species.	Projects would improve scouting methods, detection, validation and improved thresholds, new pest control products (including biopesticides), and other management improvements for growers of field and horticultural crops.	2019.086

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
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 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.	Research outcomes will identify Ontario management recommendations for potato soil-borne diseases.	2020.053

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**What are some integrated pest management strategies for horticultural bulb and brassica crop production systems that incorporate predictive models, development of economic thresholds, pesticides, alternative control measures (e.g., mating disruption strategies), hosts resistance? Important brassica pests include but not limited to Delia maggot flies, cabbage maggot, aphids.**	Improved tools for pest management are required in horticultural brassica and bulb crops. 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 some vegetable growing areas. The prospect of insecticide resistance and potential restrictions of use illustrate the importance of alternative management strategies for this insect. 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. With the loss of chlorpyrifos to a phase-out, rutabaga growers are left with no suitable options to control cabbage maggot in their crops. Cabbage maggot has been the #1 pest management priority in this crop for decades with no new solutions found.	Increased yields, fewer unmarketable crops, better management of pests and deceased cost to growers. Updated pesticide recommendations for Brassica growers. Better understanding of the pest biology to aid scouting and insecticide application. Screening up new potentially resistant lines.	2020.057

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**What non-chemical 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. This could include disease resistant cultivars, RNAi technology, or management techniques used for propagators including steam treatments.	Research outcomes will include new pest management tools and recommendations for strawberry growers to manage anthracnose fruit rot, botrytis grey mould, and other diseases.	2020.060
Integrated Pest Management	**What are chemical, biological or cultural control options for early season insect pests, like Colorado potato beetle (CPB) and wireworm, for field tomatoes and peppers?**	Due to a loss of common chemical control options and in furrow applications, transplanted tomatoes are at an increased risk to early season pest damage 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.	Research outcomes will include new pest management recommendations for transplanted field tomatoes and the registration of new products for use on CPB and wireworm on field planted tomatoes and peppers.	2020.061

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**Can mating disruption strategies, including puffer systems and sterile insect release be implemented in Ontario for control of key horticulture pests? (e.g., codling moth, oriental fruit moth, apple maggot, apple leafcurling midge, San Jose scale, Delia maggot flies, cucumber leaf beetle)**	Due to the loss of broad-spectrum control products, increase in environmental stewardship and concerns with resistance management, non-chemical alternatives are needed. Preliminary work with regional puffer systems and sterile insect release has been done in NE and NW United States but has not been validated in Ontario climate and topography. Due to the life cycle of leafcurling midge and San Jose scale, these pests would be excellent candidates for mating disruption.	Research outcome would identify new tools and strategies to manage key pests.	2020.062
Integrated Pest Management	**Can new integrated pest management (IPM) technology or strategies such as smart sprayer systems, application techniques, cultural management, detection tools, drones or automated pest monitoring be implemented in horticulture and field crops to improve pest management programs, improve environmental stewardship, provide efficiencies in labour, reduce worker exposure and minimize re-entry restrictions? What are the economics of these technologies?**	New technologies to aid horticultural crops with spraying, scouting and identification have recently been developed. Many of these technologies have great potential to increase the effectiveness of our IPM programs, reduce worker exposure or environmental impact and improve labour efficiencies. 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.	2020.063

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**Which varieties could benefit from breeding for pest resistance? Are there improved methods to breed varieties (e.g., ornamentals that are pest and disease resistant in the greenhouse, warehouse and vertical farming sector) that satisfy consumer demand?**	Most agricultural crops include the cultural control of breeding for disease/pest resistance as part of their standard IPM programs. Some areas (e.g., floriculture) are lagging where plants are bred mostly for aesthetics and growing vigour. However, recent outbreaks of devastating pests (e.g., impatient downy mildew) demonstrate disease/pest resistance can be incorporated while still satisfying consumer demands (e.g., biofilms harbouring oomycetes).	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.	2020.065
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, warehouse, and vertical farm 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 integrated pest management (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.	2020.066

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**What novel integrated pest management (IPM) strategies (e.g., monitoring programs, forecasting models, cultural controls, chemical and biological controls) can be developed for new and specialty crops with limited to no existing pest control options available? Pest issues of concern include, but are not limited to: caterpillars on hops, hemp, cape gooseberry, tree nuts and quinoa; emerging fungal diseases (downy mildew, Diaporthe) on hops and hemp; and plant bugs on quinoa, grain amaranth and herbs, downy mildew on organic and conventional basil, Pytophthora root rot on lavender, and assessing the impact of indirect pests (e.g., defoliating insects) on yield and quality of haskap and hazelnut.**	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.	2020.067
Integrated Pest Management	**How do we increase capacity to develop and access clean plant material or new pest-resistant cultivars for Ontario specialty crop growers (e.g., development of micropropagation techniques, monitoring, development of low-cost tests for other diseases or viruses, evaluation of resistant cultivars against Ontario pest strains)?**	Systemic diseases present in planting material and a lack of disease-tolerant cultivars is a major barrier to viable specialty crop production in Ontario. Systemic diseases lead to reduced yield and quality and necessitate intensive pest management, greatly increasing COP of these crops. Key pest/crops requiring clean planting material include viruses in hops, sweet potatoes and haskap, phytophthora in lavender cuttings, downy mildew in basil and eastern filbert blight and bacterial blight in hazelnuts.	Disease-free planting material and pest-resistant cultivars available for major specialty crops in Ontario.	2020.068

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**Thorough literature review of what strategies (agronomic, in-field, post harvest) are most efficacious to reduce the impact of mycotoxins/DON, provide the most value to the whole value chain to drive future research direction. Develop management strategies and tools (e.g., breeding, hybrids, in-crop management, fungicides, post-harvest remediation) to reduce the impact of mycotoxins/DON across the whole value chain. Projects must include economic analysis.**	DON was a significant issue for Ontario growers in 2018 (and has been locally significant issues in other years) and was identified as a top priority for industry in 2019. DON reduces marketability of corn, costs corn and livestock producers. Knowledge is required to better understand mycotoxin producing pathogens and associated fungal toxin accumulation in the field and in stored grain in order to improve effective management strategies. There is a need to prioritize efforts which will have the most meaningful impact on reducing the economic impact of DON throughout the value chain.	Thorough literature review/economic impact research throughout the entire value chain (breeding, grower, processors, livestock producers) to determine the 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. Research outcomes will reduce the impact of mycotoxins on corn marketability and utilization. Focus on in-season management options for growers - disease and disease-inducing pest forecasts, optimum application stage guidelines, fungicide active ingredient and application method/timing/technology evaluations for improved recommendations. Develop an Integrated Disease Management (IDM) approach - interaction of management practices with other crop protection products, cropping practices, inputs, cover crop or weed hosts etc.	2020.070

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**Improved understanding of western bean cutworm (WBC) activity, crop preference, crop phenology, scouting methods and detection tools (including detection of pesticide and transgenic resistance), action thresholds, biocontrol's (e.g., nematodes), 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., Growing Degree Day 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.	2020.071

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**How can robotic and artificial intelligence systems supplement existing agronomic practices such as planting of seeds or transplants (e.g., corn, soybeans, etc.), weeding of row crops (grain, oilseed and horticulture), surveillance of pests/diseases, identification/rouging of male flowers (e.g., hemp/cannabis), pollination (e.g., hazelnut) and debudding/berry harvesting (e.g., ginseng)? How will new robotic technology in field work be integrated into current production systems? How can these systems help with effective sharing of pest and disease information among plant agriculture sector members/ partners? Projects must include cost benefit analyses and efficiency assessments.**	Many robotic and unmanned technologies are under development and it is likely we will see a fundamental change in farm equipment. Robotic weeding systems are being tested and may offer new integrated pest management (IPM) strategies for herbicide resistant and hard to control weeds. Robotics may improve the ability to screen young seedlings (hemp/cannabis) to identify and remove male plants would be of tremendous benefit to these industries as the presence of male plants is detrimental to cannabinoid yields. Robotic seeders may offer opportunities to reduce soil compaction. There are many innovations on the horizon that may change the way these crops are farmed.	Development of robotic and AI systems would improve the efficiency of existing agronomic practices and reduce labour costs, thereby improving the competitiveness of Ontario farmers. Additional benefits may accrue such as reduced soil compaction, improved site-specific management across a field or of individual plants.	2020.074
Integrated Pest Management	**How can the occurrence and distribution of pesticide resistant pests (including but not limited to: Bt resistant corn rootworm, apple scab) be better understood? Develop management strategies to reduce selection pressure on crop protection tools and address the loss of key pest management tools on fruit, vegetable, ornamental and field crops.**	With the loss of several key pest management tools expected in the next few years, there will be an increased reliance on crop protection materials that have a high risk of developing resistance. Pathogens, insects and weeds that have developed resistance to crop protection material can threaten production, including pests which are not yet in Ontario but have potential to expand into Ontario crops. Integrated pest management (IPM) programs for some Ontario crops will require re-assessment to determine where gaps may occur in crop protection.	Research outcomes will strengthen recommendations on pesticide use, identify new or alternative management tools for crop protection, and develop best management practices to reduce the occurrence and spread of resistant pests.	2020.075

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**Can we increase our understanding of the impact of viruses on Ontario specialty crops (e.g., hops, hazelnuts, lavender, sweet potatoes, haskap) and conventional horticulture (e.g., apples, berries, grapes) and identify possible management techniques?**	Viruses are a significant pest issue for Ontario specialty crop growers. High levels of virus have been documented or are suspected in these crops; however, they cannot be controlled with pest control products. In addition to the development of sources of clean plants, growers need the ability to inexpensively test for these viruses, an increased understanding of their impact on yield and quality so they can determine when management is warranted, and the identification of potential management strategies for these pests.	Specialty crop growers can effectively detect viruses in their crops and make sound management decisions.	2021.048
Integrated Pest Management	**Can effective controls be identified for vertebrate pests in specialty crops or other horticultural crops, in particular: squirrels and jays in hazelnuts, birds in haskap and deer and voles in specialty tree fruits and ginseng?**	Vertebrate pests are major sources of crop loss in hazelnuts (birds, racoons, squirrels and deer) and many berry crops, especially haskap (birds, deer, rabbits). Vertebrate control requires a multi-pronged approach and there has been limited work to date on the most effective methods for managing these pests in Ontario. Vertebrates can cause almost total crop loss in hazelnuts, haskap and many other horticultural crops.	Research outcomes will identify cost-effective methods for reducing damage due to vertebrates in Ontario specialty and other crops.	2021.049

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**How can effective management options for soil insects (grubs and wireworms) in specialty root crops (ginseng, sweet potatoes and tiger nuts) be identified, where broad spectrum insecticides typically used for control cannot be registered due to restrictions on label expansions for these products?**	Grubs, wireworms and other soil insects cause major losses to specialty root crops, in particular ginseng, sweet potatoes and tiger nut. Imidacloprid is currently registered for grub control on ginseng and sweet potatoes, while there is nothing registered for soil insects on tiger nut. In light of pending re-evaluation decisions on neonicotinoids, alternative controls are required, including other pest control products as well as potential biological, cultural or mechanical controls.	Decreased losses to soil insects in Ontario specialty root crops.	2021.050
Integrated Pest Management	**How can the impact of and management options for invasive fruit flies (spotted wing drosophila or SWD, and European cherry fruit fly) in haskap be assessed?**	Haskap is an important emerging berry crop for Ontario. Haskap has traditionally escaped SWD damage due to its early harvest date, but earlier SWD peaks and later-ripening varieties are leading to increased damage of this pest in Ontario. The impact of European cherry fruit fly must also be assessed on haskap, since wild honeysuckle is known to be a preferred host of this pest.	Research outcomes will provide an accurate assessment of the potential impact of invasive fruit flies on haskap in Ontario as acreage increases and identify promising chemical and non-chemical management options.	2021.051

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**What integrated pest management strategies can be developed for horticultural and field Brassica crop production systems (e.g., canola) that incorporate pesticides, alternative control measures, hosts resistance and/or take a systems approach to controlling swede midge?**	Swede midge continues to be the #1 threat to spring canola production in Ontario and is the cause of decreasing acres and profitability. Canola is a highly valuable crop in northern regions, and a valuable crop for lengthening rotations in general. End users would value a larger local supply of canola rather than shipping grain from western Canada. Canola is also a valuable resource for many pollinators. We do not yet have highly effective control measures for swede midge. A beneficial parasitoid exists but has not been fully studied.	An integrated management protocol is developed for managing swede midge that considers beneficial parasitoids.	2021.052
Integrated Pest Management	**What novel products (biological or chemical) and/or strategies for control of stink bugs in tomatoes and peppers are available or could be developed?** **Note: Proposals must include a Value Assessment Plan.**	Stink bugs are a notoriously difficult pest to manage and with the loss of all but one application of thiamethoxam per year, control options are extremely limited. Growers are suffering losses in their fresh market tomatoes and peppers and processing tomatoes due to stink bug damage making them unmarketable.	Improved management strategies and/or novel control products to give growers more tools to control stink bugs	2021.054

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**How can the distribution and improved management of Phytophthora capsici and Pythium spp. in fruiting vegetables (e.g., tomatoes, peppers, cucumbers) be better understood?**	Phytophthora capsici is a soil borne pathogen that can affect a variety of crops including, but not limited to, tomato, pepper and cucumber. Spores can last in the soil for 10 years or more years and management of the disease is extremely difficult. The pathogens Phytophthora capsici and Pythium spp. cause economic losses in fruiting vegetables due to fruit rots and dieback. Control strategies for these pathogens are limited. An integrated approach to controlling these oomycete diseases is required to maintain productivity in these crops.	The distribution of P. capsici in Ontario is likely much wider than we are currently aware of, and many growers are likely affected without knowing the cause of the problem. Research outcomes will include an integrated approach (e.g., chemical or biological or cultural control strategies in the crop, soil, irrigation water, etc.) to controlling diseases caused by the oomycete pathogens Phytophthora capsici and Phythium spp. In fruiting vegetable crops such as cucurbits and tomatoes.	2021.055
Integrated Pest Management	**How can scouting/detection and prediction of two-spotted spider mites in soybeans and dry beans, and identification of pesticide resistance be improved. Can new pest management solutions including insecticides, biopesticides and biocontrol options for spider mites in soybeans be identified?**	There is only one insecticide active ingredient (dimethoate) registered for spider mite control in soybeans and dry beans and resistant populations have been identified in Ontario. Spider mite are very difficult to scout for (aside from observing crop damage) because they are extremely small so additional tools are required for detecting the presence of spider mites and identifying resistant populations. Spider mites spread very quickly and cause extensive damage when not identified and controlled promptly.	Improved scouting techniques will result in reduction of unnecessary insecticide applications. Alternative control mechanisms and/or insecticide options will mitigate development of resistant populations and improve crop protection.	2021.056

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Integrated Pest Management	**What is the presence of alfalfa snout beetle in Ontario fields? What are the best management practices (BMPs) for effectively managing infestations, including development of resistant alfalfa varieties?**	Alfalfa snout beetle is a regulated pest in Canada that causes significant yield and stand losses in alfalfa. A 2008 survey determined the infestation covered 150 km^2 in eastern Ontario. Insecticides are not effective on this pest, so other modes of management (e.g., cultural, biological) are required to prevent further spread of alfalfa snout beetle.	An updated understanding of the size of the infestation in Ontario. BMPs for alfalfa growers to minimize the damage caused by alfalfa snout beetle on their farms and prevent the spread of alfalfa snout beetle to new fields.	2021.057
Integrated Pest Management	**Corn rootworm and Bt resistance: 1. What are new effective rootworm management tools to reduce risk of resistance development to Bt traits and soil applied insecticides? 2. what methods, tools and resources are needed to help influence behavioural change to encourage crop rotation options away from continuous corn? Why do these methods work? Determine the most sustainable approach to corn rootworm management in areas with Bt resistance. 3. How can predictive tools for key corn pests be improved and what influence and impact climate change will have on the phenology, impact and management of corn rootworm?**	Corn is grown on approximately 2M acres in Ontario, and corn rootworm resistant to Bt traits has been confirmed. Bt traits are the key method by which corn rootworm has been managed in Ontario. Damage by corn rootworm causes lodging and high levels of yield loss. Livestock producers are reliant on corn silage and are most at risk of resistant corn rootworm as they have corn-heavy crop rotations. Insecticide seed treatments are facing increased restrictions or loss of use, and soil applied insecticides are difficult to fully adopt given equipment requirements. Other management tools and practices are required to limit risk of resistance development of remaining control options.	Integrated pest management (IPM) practices for corn Bt resistant corn rootworm are well understood, communicated, and implemented across Ontario. Expansion of Bt resistant corn rootworm across regions is mitigated, corn yield protected, and Bt technology remains viable in Ontario.	2021.058

Soil Health

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Baseline Soil Health Information	**What are best cost-effective indicators of biological soil health to assess soil functions? Functions include soil nutrient supply, carbon cycling and storage, soil structure and water dynamics, plant health and productivity.**	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 recommended measures in a way that is supported by science and minimizes cost. Examples of projects in this category: Comparing Potential Mineralizable Nitrogen (PMN) to Autoclaved Citrate Extractable (ACE) Protein Index for measuring soil Nitrogen (N) supply, and can permanganate oxidizable carbon (POxC) be used to infer future changes in Soil Organic Carbon (SOC)?	Research will inform improvements in measuring biological health through better indicators or more cost-effective methods for current indicators. Both outcomes would improve uptake of, and management decisions from, soil health tests.	2020.078
Baseline Soil Health Information	**How should soil health tests or indicators be evaluated for accuracy, saliency, and interpretability? What is the minimum dataset (MDS) required for soil health tests that are accurate, cost effective and interpretable? What are best cost-effective indicators of soil health to assess specific soil functions?**	Greater certainty is needed regarding what constitutes an effective and practical soil health test. Producers and their advisors require tests that are practical to perform, accurate in quantifying soil health status and that guide improved soil 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.	2020.079

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Baseline Soil Health Information	**How do the interactions between cover crops and other components of the crop production system (e.g., tillage, fertility, crop protection) influence the economic and environmental effects of including cover crops in the system? How would this contribute to furthering the understanding of the economic and environmental role of cover crops alone and in combination with tillage and other components of the overall crop production system.**	Two million acres of soybean grown in the province remain soil bare during the non-growing season, which has been shown to be the time of greatest erosion (wind, water, tillage) and nutrient loss. Cover crops and reduced tillage help to stabilize soils during the non-growing season and are known to improve soil health and environmental fitness in many ways, yet so many acres remain bare each winter.	Better understanding of cover crop management within production systems - with emphasis on reduced risk to cash crops and increased soil benefits - should lead to greater adoption of these practices. Greater adoption will reduce environmental consequences of crop production and over time enhance the economic performance of Ontario's crop production systems.	2021.059
Environmental Impacts of Management Practices	**How do we determine the actual economic and environmental impact of soil compaction? Are there scientific methods and/or sensors already available or that can be developed and validated to measure i) the on-the-go stress applied by rolling equipment, ii) the ROI of compaction, and iii) the environmental impact of soil compaction across variable soils? What are the immediate and longer-term economic and environmental effects?**	Soil compaction is happening as springs and falls become wetter and farm equipment continues to get larger. The agricultural sector continues to be unable to measure the real impacts, either economically or environmentally. As equipment moves through a field the changing load and landscape makes the assessment of this very difficult.	By understanding the economic and environmental consequences of soil compaction with hard numbers, producers can have the required information for consideration of adoption of practices and technologies to reduce soil compaction. Without having hard verifiable numbers on the cost of soil compaction, the sector will continue to struggle to get people to invest in the management and technologies to address this issue.	2020.080

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Water Quality and Quantity

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Analysis of BMP Adoption	**What are the most cost-effective management practices for producers to reduce phosphorus runoff issue on farms? How can switchgrass and miscanthus be used as filter media and as vegetable buffers to capture phosphorus?**	Phosphorus contamination is an issue in the Great Lakes basin. Switchgrass and miscanthus can potentially be used in erosion control technology ('socks') as filter media for capturing phosphorus from surface runoff water. This research would examine the costs to producers and the expected environmental benefits of this technology. The research could examine the potential use of bio crops as filter media. A best management practices for phosphorus reduction.	The research will provide evidence to address the Canada-Ontario Lake Erie Action Plan on reducing phosphorus loading by 40 per cent with agriculture playing an important role.	2021.064
BMP Development	**Considering recent synthesis research on buffer strips, 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 water?**	Buffers are multifunctional yet have been 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 would be helpful.	2020.007

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
BMP Development	**What is the composition of milking centre washwater (e.g., total suspended solids, biological oxygen demand, nitrogen content, phosphorus content) for various system and livestock 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 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?**	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. 267/3 under the Nutrient Management Act, and Ontario's Building Code (OBC), pertaining to treatment and disposal of dairy milking centre washwater. O.Reg. 267/3 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".	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 support harmonizing the requirements of O.Reg. 267/3 and the Ontario Building Code, with respect to disposal of milking centre washwater, and economic assessment of any required treatment or disposal technologies.	2020.008

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Environmental Impact of Management Practices	**What are the differences in phosphorus losses in different cropping production systems? How are different forms of phosphorus transported from fields with highly erodible soils to rivers (e.g., dissolved phosphorus, vs. organically bound phosphorus vs. clay-bound phosphorous)?**	While there is research relating to soil bound particulate phosphorus from the last three years, there is still more to be understood regarding the issue of dissolved reactive phosphorus that results from excess and legacy phosphorus in sediment, streams, rivers, and lakes. A better understanding of phosphorus forms, pathways, and transport mechanisms in both wet and dry growing conditions is needed.	Comprehensive yet simplified schematics of phosphorus forms, pathways, and transport mechanisms in agricultural productions systems would be the research outcome.	2019.006
Environmental Impact of Management Practices	**Conduct a meta-analysis/synthesis of phosphorus losses from cropland research in the Great Lakes Region in the last 10 years.**	To better understand the extent of the problem of phosphorus losses from cropland, a meta-analysis of existing studies can put the problem in context and to compare and contrast the findings from different production systems in different study sites.	A quantitative state of the science of phosphorus losses in the Great Lakes Region in the last decade will be produced.	2019.007

Sustainable Production Systems

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
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 soybean rotations?**	Corn and soybean production in southern Ontario have been considered 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. This research can inform pasture management and forage production best management practices to support the diverse Ontario agricultural sector and foster greater competition with other jurisdictions.	A report for corn and soybean producers that examines ways to incorporate more perennial crops in corn and soybean rotations while maintaining or increasing profitability and quality is the desired outcome from this research.	2019.014
Analysis of BMP Adoption	**How could food waste be reduced in Ontario's food related businesses such as restaurants, grocery stores, and the food processing industry? What type of behaviour or operational changes would be most effective at reducing food waste?** **How can businesses be encouraged to participate in the rescue of surplus food and donation of good, perishable food to food rescue organizations?** **How can the financial opportunities by food rescue be demonstrated?**	There needs to be a better cost/benefit analysis of food wastage in sectors such as the food service industry. Increased knowledge of lost money by customers and food service establishments can lead to a reduction in food wasted.	The research outcomes will highlight insights that will serve to help decrease in food waste in food service establishments.	2019.018

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
BMP Development	**How do Ontario crop fertility recommendations meet the needs of modern production practices and modern crop varieties, cultivars, hybrids of all crop types?**	Crop fertility recommendations developed in past decades may not address the needs of modern crops in both field crops and horticulture crops production systems. 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. There is also a need for fertigation recommendations in orchard systems. Important horticulture crops include but are not limited to: Potato, Ginseng, Asparagus, Hazelnut, tender fruit, grape and high-density apple orchards.	The desired outcome is that Ontario fertility recommendations reflect the current state of production advancement.	2019.029
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, etc.). How can they be used to increase their contribution to sustainability objectives, and are there any implications for non-stewardship programs?**	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 will assist the ability to understand the impact of Business Risk Management (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).	2019.031

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
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, etc.)? 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?**	Cover crops continues to be an important practice for soil health and nutrient management.	The research outcomes will provide a clear understanding of the level of adoption of cover crops in Ontario, including regional differences and information gaps that hinder measuring progress.	2020.003
BMP Development	**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 or less stringent regulations produce a measurable improvement and impact to the environment? What are the economic costs and benefits to the agricultural sector of these regulations?**	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, 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.	Outcomes of this research would include a cost-vs-benefit analysis of environmental regulations pertaining to agriculture and an assessment of how the desired environmental outcomes would be affected by increase and or decrease in regulations, and an economic analysis of those regulations.	2020.004

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
BMP Development	**To what extend does net pen aquaculture impact the benthic invertebrate community below net pens? What is the assimilative capacity of benthic invertebrates in response to aquaculture inputs (feces, waste feed, etc.)?**	Feed quota increases have been issued by the MNRF and will result in greater nutrient inputs at net pen sites over the next years. The resulting 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.	The research outcomes will provide insights to accurately identify the assimilative capacity of benthic invertebrates in response to aquaculture inputs. This information could be used to informed sustainable production levels for net pen aquaculture.	2020.020
BMP Development	**What novel crop management systems can be developed which enhance economic and environmental benefits in field crop production, for example, multi or relay cropping, including forages, canola, cover crops, and/or other fall seeded crops in rotation? How do these systems affect the economic, agronomic and environmental impact of the whole cropping system?**	This research could help address the following questions. Could diverse multiple species of crops be grown in the same landscape at the same time and separated post harvest? Would this lead to more diverse and resilient systems of production that would capture more economic and environmental value than current mono, annual crop approaches to crop production? For example, could Canola coffer additional benefits (i.e. offers soil health benefits and habitat for pollinators).	The desired outcomes include the analyses of new management practices which increase diversification of crop rotations, including on-farm economics, landscape-level impacts, environmental benefits.	2020.040
BMP Development	**How can feed efficiency be improved through animal and plant breeding and feeding strategies to optimize livestock performance and reduce input resources? What increased understanding of the impact of genetics, management, and environment can be achieved?**	Feeding and breeding strategies to improve feed efficiency have been identified by the Beef Cattle Research Council as a priority to improve sustainable beef production systems, reduce inputs, improve profitability and reduce the carbon footprint of the beef sector.	The research outcomes will Identify breed traits that show improved feed efficiency and identify feed strategies to improve intake, average daily gain, and feed efficiency and carcass quality.	2021.012

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
BMP Development	**What best management practices are funded as part of stewardship programs in other provinces and the United States? How do these compare with Ontario? The research should also consider how land prices vary in the different jurisdictions examined.**	For the Ontario agri-food sector to achieve success in environmental stewardship, an understanding is needed on how other jurisdictions in North America are incentivizing the adoption of best management practices.	A jurisdictional analysis of agri-environmental stewardship programs available to producers in North America will be outcome of this research	2021.025
Climate Change Resiliency	**What are the environmental outcomes of perennial agriculture biomass crops and feedstocks (e.g., possible outcomes include: greenhouse gases, decreased nutrient runoff, habitat/biodiversity)?**	Research results will highlight additional opportunities for the agri-food sector to address environmental issues including climate change.	Results of this research can contribute to Ontario's efforts in addressing environmental issues and reducing the greenhouse gas emissions footprint.	2019.036
Climate Change Resiliency	**What are the global and domestic market trends with respect to the use of sustainability standards (e.g., trade requirements, retail sourcing requirements, etc.)? What are the implications for Ontario's agri-food sector (e.g., growth opportunities, competitiveness issues)?**	As the global demand for sustainably produced food, fibre and fuel increases and becomes a stronger driver of market access and 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.	This research will provide 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.	2019.040

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Climate Change Resiliency	**How best can integrating annuals into the annual grazing regime reduce or mitigate the impact of drought caused by summer drought period?**	Drought is no longer an unusual event but is now an annual event in Ontario which has significant impacts on pasture production and consequently leads to the feeding of forage saved for winter feed - this leads to a reduction in the carrying capacity, productivity and increased cost of production on many Ontario beef farms. Integrating annuals into the grazing regime would reduce the impact of drought but little information is available on which annuals are best suited to use during these summer drought situations	Increased knowledge about which annuals are best suited for producers to grow to enable grazing to be provided during the summer drought period. In addition, how these annuals are integrated into a permanent pasture situation is critical for uptake by beef producers. Research could show that adopting annuals to provide summer grazing may significantly reduce the cost of production by avoiding the need to feed forages intended for winter feeding.	2021.013
Environmental Impact of Ag Production	**How can the amount of food waste being generated by households and consumers be reduced? What are the most effective best practices currently in use to educate the public and change behaviour with regards to food waste?**	There are barriers that exist to increasing the amount of surplus, edible food that is being recovered in Ontario (including infrastructure gaps and social attitudes, such as misconceptions about perishability and stigma associated with recovered food).	The research outcomes will provide insights to decrease the amount of excess food going to landfill and promote food recovery as a means of reducing food waste in Ontario.	2019.033

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Environmental Impact of Ag Production	**What are the costs and benefits of producing crops on marginal soil/land versus other land uses in Ontario? What is known about the economic value of maintaining and restoring wetlands, woodlands and other natural areas in proximity to crop production in Ontario? What are the best ways to measure? What are the costs and benefits of different stewardship practices on marginal land?**	There is a lack of data to support decision making about the cost benefit of crop farming on lands that are considered low yield potential (i.e., poor soil, former wetlands and low area etc.)	With the insights from this research better decision making with occur and increased environmental benefit will be enabled.	2019.035

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Environmental Impact of Ag Production	**Can pH of organic amendments (e.g., digestate, Lystegro, hog manure, etc.) be managed to reduce nitrogen losses?**	General pH is not regularly tested in manure, but high pH (>7.7) increases nitrogen (N) volatilization in the first few hours of application. N supplied by the material is much lower than expected and often not supplemented with commercial sources. Research that could explore the pH level at which N losses occur more quickly. High pH is a constant in most anaerobic digestate and Lystegro, but not in manure. What leads to high pH (feed additives such as dried distiller grains?)? What strategies would be economic to keep pH near 7?	This research could provide improved: - prediction of available nitrogen from organic sources with high pH materials -understanding of role of pH in N volatilization, -understanding of whether additives (lime/N inhibitors) can economically reduce pH and N losses in storage and/or when field applied, - knowledge of feeds or feed additives or management practices that increase manure pH in specific operations (liquid hog, solid ruminant) - improved predicted available nitrogen from organic sources with high pH materials. This research will also contribute to the understanding of: • At what pH level does N volatilization increase, • Are there any economic additives (lime/N inhibitors) that will reduce pH and N losses in storage and/or when field applied, and • Knowledge of feeds or feed additives or management practices that increase manure pH in some operations (i.e. liquid hog, solid ruminant).	2021.060

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
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.	2019.021
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 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 to take necessary steps to support risk mitigation.	2019.022
Environmental Impacts of Management Practices	**How can additional food and agriculture waste processing capacity be incented in the province? Are there any barriers currently in place? How can additional processing capacity that not only diverts food and agriculture waste but also results in a beneficial end product be encouraged? Are there other opportunities to up-cycle organic waste materials currently being sent for composting or anaerobic digestion?**	The location of food and agriculture wastes are often located far from the farms needing soil amendments. In addition, such soil amendments are often not widely available or are available at prices too high for widespread use. There needs to be greater understanding of the organizational approaches that would enable efficient acquisition of organic amendments by individual farmers without high transaction costs.	Research outcomes will provide insights to assist in the ability to increase the amount of recovered food and agriculture waste.	2019.023

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Environmental Impacts of Management Practices	**What are the barriers for municipalities and private processors to begin accepting and processing certified compostable products?** **What system changes would be required for organics processing facilities to accept and process compostables (as currently facilities are designed to primarily manage food waste and may need upgrades to process compostable products and packaging)?**	Additional research is needed to address the issue of compostable products and packaging such as cutlery, cups, take-out containers, and coffee pods not being accepted in municipal organic waste collection systems in Ontario.	The research will help support food processors and businesses invest in environmental solutions and may assist in the reduction of barriers to accepting compostables.	2019.024
Environmental Impacts of Management Practices	**Research is needed to investigate the extent, presence, and concentration of environmental chemicals (agrochemicals and agrochemical residues) in bee hive products (honey, wax, pollen, propolis, etc.) as well as investigate the adverse effects of these chemicals, including synergistic effects, on bee health, bee reproduction and the environment.**	There are ongoing concerns and risks of pesticides to the bee populations. Addressing these in a science-based approach will allow beekeepers and growers to focus on risks mitigation and well as refining integrated pest management.	This research will result in better knowledge of the potential exposures that impact honeybees, at which times of year and at what levels, provide better guidance to growers and beekeepers on strategies to reduce pesticide risks and help in identifying which pesticides and patterns of use are lower risk.	2021.069
Innovative/Disruptive Technology Development	**Research is needed to validate precision agriculture protocols and equipment for Ontario agricultural systems and identify opportunities for economic gain and environmental protection. An assessment of the differences between precision agriculture and precision conservation and how**	There are multiple methods and approaches to developing management zones and prescription maps for precision agriculture. The absolute and relative merits of different approaches are largely unknown, and specific methods are often used differently. Growers and advisors need guidance to evaluate options that are being marketed.	This result will provide vetted and accepted precision agricultural protocols to inform management decisions and agri-environmental programming. Best practices for specific tools (e.g., electrical conductivity (EC), electromagnetic induction (EM) mapping, digital elevation model derivatives)	2019.043

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
	producers understand these terms is also needed. **Note: Proposals must include a Value Assessment Plan.**			

Productive Land Capacity

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Evidence to Support Land Use Policies	**Are there other approaches to land use planning and farmland protection in other jurisdictions, including both land use policy and regulations, taxation, and other tools and approaches (e.g., differential taxation, current agricultural use value and compensation), that could be adapted to Ontario, and which would support and complement current approaches?** **Research should take into account what is being done to support COVID recovery of the agri-food sector with emphasis on ensuring farmland is protected so the agri-food sector can thrive.** **Questions to integrate into this work can include: What emerging agri-food sector trends, COVID responses and public interests (i.e., food security and environmental sustainability) provide opportunities to strengthen the protection of farmland in Ontario?** **How could Ontario's approach to the long-term protection of farmland be refined to better integrate and strengthen not only land use planning but economic development and environmental stewardship?**	Through recent changes to the policy led land use planning system in Ontario, the province now advocates the use of 'agricultural systems approach' to integrate land use planning and economic development to foster a thriving agri-food sector, while ensuring the long-term protection of farmland. The adoption of this approach has provided dividends, such as increased awareness about the importance of farmland protection, the need to support agricultural infrastructure, and land use policies that assist the sector to thrive, e.g., robust permitted uses policies, and requirements for agricultural impact assessments. Despite these policy innovations, significant challenges remain in many areas of Ontario, and long-term farmland protection continues to be threatened by competing land use needs and the challenge to balance competing priorities for other land uses. Farmland continues to be lost at a rate that is not sustainable. Current policies only slow the rate of farmland loss. There is a need to consider whether the 'agricultural system approach' can be enhanced or if there are other complementary new tools and approaches that are needed in Ontario to ensure farmland is protected for future generations.	This research will assist with: 1. Identify and evaluate approaches to land use and farmland protection in other jurisdictions, including both policy, land use planning, taxation, and other non-planning tools and approaches. 2. Identity current and potential future opportunities to integrate environmental stewardship and food security into provincial approaches and policies related to land use and farmland protection. 3. Increase uptake of on-farm environmental stewardship practices. 4. Identify opportunities to improve land use planning policies to incorporate agri-environmental policies. 5. Demonstrate the significant role of farmland protection and stewardship to Ontario's food supply and the resilience of the Ontario's agri-food system.	2021.023

Competitive Production Systems

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Improved Management Processes	**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?** **Note: Proposals must include a Value Assessment Plan.**	Existing livestock barn ventilation systems are generally designed to manage only temperature, 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. 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.	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.	2019.053

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Improved Management Processes	**What is the economic viability and environmental sustainability of small-scale land-based recirculating aquaculture systems (RAS) for the production of market size Salmonids?** **Note: Proposals must include a Value Assessment Plan.**	Land-based RAS aquaculture for market size Salmonids is a new and emerging mode of aquaculture production with major worldwide development projects currently established or in development. The economic viability of RAS aquaculture producing market size Salmonids has not been demonstrated and a better understanding of the environmental sustainability is needed. Research supporting the economic viability and/or environmental sustainability of RAS aquaculture would initiate investment interest. RAS aquaculture can facilitate the diversification of fish production in Ontario, provide agricultural diversification opportunities for terrestrial agriculture and enhance the sustainability of Ontario aquaculture.	Applied research supporting the economic and environmental sustainability of RAS aquaculture producing market size Salmonids. Applied research supporting regulatory environmental guidelines and environmental assessment procedures for RAS aquaculture.	2020.019
Improved Management 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 evaluated and adapted for field production in Ontario (e.g., agronomy, cultivar evaluations, maximizing yield and quality under Ontario growing conditions, storage technology, packaging)?**	Information for new and specialty crop production from other jurisdictions needs to be evaluated and adapted for Ontario because it may not apply 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.	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 management practices in establishing new crops, pre- and post-harvest handling, fertility and water requirements.	2020.033

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Improved Management Processes	**What are potential techniques to increase post-harvest quality for tender fruit, apples and fresh grapes (i.e., optimal harvest timing for new major cultivars, packing and cold chain management systems, and practices to increase quality and storage/shelf life)?**	Optimal harvest timing and post-harvest research helps to increase fruit quality and shelf life of fruit.	The research outcome will contribute to the development of best management practices for harvesting and storing fruit, that will optimize fruit quality.	2020.036
Improved Management Processes	**How can Ontario livestock producers extend the grazing season through management techniques, alternative crops, and integrated crop/livestock systems?**	Livestock feed is the largest expense on livestock operations, and well-managed grazing is the cheapest source of feed for ruminant livestock. Extending the grazing season has a direct and positive impact on a farm's profit margins. Many grazing recommendations were developed in the prairies under different growing conditions and with different grass species, and do not translate well to Ontario conditions. Livestock operations are starting to graze cover crops, but it is unknown how the practice affects yields of grains and oilseeds in the rotation.	These results will be used to update best management practices (BMPs) for perennial pasture management that reflect the growing conditions of Ontario. These new BMPs for grazing in integrated crop and livestock systems will be based on grain and oilseed crop production data as well as the economics of grazing animals.	2020.039
Improved Management Processes	**Can new high yielding and high-quality crop varieties/hybrids/germplasm be developed through advanced crop breeding, new technologies and testing methods for field crops (e.g., corn, soybeans, dry beans, canola, winter wheat, spring wheat, oats, barley, forage crops)? This includes new varieties for value-added and identity preserved markets.**	Ontario requires new high yielding and high-quality grain and field crop varieties adapted to Ontario conditions through state-of-the-art breeding programs to ensure competitiveness against other jurisdictions. Crop variety genetic performance is only one important factor in selecting the best genetics. Understanding new variety performance in a wide range of environmental and management conditions will enhance selection and adoption of new varieties. Availabilities of such specialized varieties opens access to higher value markets for Ontario grains.	Varieties of grain and field crops that make Ontario farmers highly competitive in a local and global market to ensure continued access to markets and viability of the sector.	2020.047

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
	Note: Proposals must include a Value Assessment Plan.			
Improved Management Processes	**How can we determine which edible crops grown in Ontario greenhouses, warehouses, and vertical farms can be supported by the domestic market in Ontario and Canada?**	The COVID-19 pandemic exposed 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, and leafy greens make up the bulk of what is grown in warehouses and vertical farms. Some strawberries, eggplants and lettuces are also grown in Ontario greenhouses in smaller quantities. Vertical farmers are also experimenting with fruits and vegetables, such as strawberries, beans, and mini vegetables. More research is needed to increase the diversity of crops grown in Ontario greenhouses, warehouses, and vertical farms year-round by understanding which crops can be supported by the local market.	This research will contribute to a better understanding of which locally produced edible crops can be supported by Ontario and Canada markets. This would inform greenhouse, warehouse, and vertical farmers as to the crop they can grow sustainably and profitably in Ontario and could ultimately lead to increased diversity of crops grown year-round in Ontario.	2020.092

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Improved Management Processes	**What is the effect of weight at turn-out and body condition score on average daily gain at pasture from young beef cattle backgrounded in-doors over winter and subsequently on pasture?**	Research from other jurisdictions has shown that average daily gain at pasture is impacted by both weight at turn out and body condition score. There is no information available to Ontario beef producers on (a) what is an ideal body weight and body condition score at turnout under Ontario grazing conditions, (b) what is the ideal winter feeding regime using available Ontario feeds to generate this ideal body weight and body condition score and, (c) the impact of the economic value of these cattle on the ideal wight and body condition score at turnout.	This research will contribute to providing evidence to demonstrate (a) the ideal weight at turnout that will maximise average daily gain at pasture, (b) the ideal body condition score that will maximise average daily gain at pasture and, (c) potential revenue return from optimising weight at turnout.	2021.009
Improved Management Processes	**What are the optimal production practices for adzuki beans in Ontario and by soil type, e.g., practices could include reduced tillage, crop fertility management?**	Adzuki beans are one of the highest value field crops and are the highest value dry bean grown in Ontario. Acreage for adzuki beans has been steadily increasing. They are a different species than all other dry beans grown in Ontario and respond differently to management than other market classes. A comprehensive production guide for adzuki in Ontario and on different soil types is required to improve production and reduce crop insurance claims, including tillage types, plant populations, fertility requirements and placement, crop rotation, herbicide safety, bacterial disease control, white mould control and insect management.	A comprehensive adzuki bean management guide which is available for Ontario dry bean growers, resulting in improved yields and reduced crop insurance claims, and improving profitability.	2021.032

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Improved Management Processes	**What are the best management practices for meat sheep mature body size?**	Animal agriculture farming needs to improve to meet public expectations of a small environmental footprint. Many factors must be balanced to ensure financial viability and reduced environmental impact. Mature body size affects feed intake, manure production and greenhouse gas (GHG) emissions.	The development of best management practices for mature body size and a measure or algorithm that balances mature size, lamb production, resource usage and environmental impact. The measure or algorithm will allow producers to adjust mature size as resources, production and environmental impacts change leading to a reduction in environmental impact per pound of lamb produced.	2021.033

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Improved Management Processes	**How can on-farm management practices, such as genetic selection, nutrition, out-of-season breeding, or extended lactations, be used to improve small ruminant (sheep and goat) milk composition (e.g., fat, protein, fatty acids, somatic cell count)? What is the economic impact of selection for favourable Alpha S1 Casein genotypes on milk processing and product quality in Ontario?**	Sheep and goat milk composition is a key component of a competitive production system. For both dairy goat and dairy sheep operations, milk composition and quality play an important role in economic success. Throughout the year protein, fat and milk quality fluctuate with higher components in the winter compared to summer months, but with reduced quality and yields. There is limited information at the individual animal or herd level of the impacts of genetic selection, nutrition, extended lactations and out-of-season breeding on milk quality and milk composition. Research in this field would improve knowledge on how producers can achieve consistent milk supply throughout the year and its impact on economic viability. Alpha S1 Casein genotypes are associated with protein and fat yield, which are important to cheese processing, and associated with reduced human sensitivity to dairy products. Research is needed to determine the feasibility of Alpha S1 Casein genotype selection in the Ontario goat population.	This research will result in (1) an improved understanding of the impacts of protein and fat yield on economic viability of Ontario dairy goat and sheep operations and, 2) the development of best management practices (BMPs) to achieve ideal milk composition through on farm practices (e.g., genetic selection, nutrition, breeding management).	2021.034

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Improved Management Processes	**How can the prevalence of chronic infectious diseases (e.g., Johne's Disease, Caprine Arthritis Encephalitis, Maedi Visna and Caseous Lymphadenitis) in the Ontario small ruminant (sheep and goat) sectors be reduced through on-farm management practices such as genetic selection, vaccination, and replacement rearing procedures?**	Chronic infectious diseases such as Johne's Disease (JD) Caprine Arthritis Encephalitis (CAE), Maedi Visna (MV), and Caseous Lymphadenitis (CL) are profit-limiting, due to reduced production and increased involuntary culling, in Ontario small ruminant herds and flocks. The prevalence of CAE in Ontario dairy and meat goat herds was estimated to be 80.4% and 17.0%, respectively (Stonos et al., 2013). These diseases are challenging to detect and control as they are primarily adult-onset and the infection may persist sub-clinically for months or years. Available control strategies and prevention are often highly expensive and have significant labour requirements (e.g., snatch and rear of replacement animals and colostrum replacement to prevent CAE transmission). The effectiveness of various management strategies such as colostrum replacement compared to heat-treated colostrum is not well-known. Research on cost-effective control programs (e.g., genetic selection, vaccination, replacement rearing procedures) for chronic infectious diseases were reported as a high research priority by the Ontario goat sectors.	1) Best management practices (BMPs) for the control of specific chronic infectious diseases for Ontario small ruminant flocks and herds. 2) Greater understanding of the impacts (e.g., economic, labour, animal welfare) of chronic infectious diseases and their control in the Ontario small ruminant sectors. 3) Novel cost-effective tools and strategies (e.g., genetic selection, vaccinations) to reduce the prevalence of these diseases.	2021.035

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Innovative/Disruptive Technology Development	**What are some labour-saving technologies (e.g., automatic, mechanic, chemical and/or precision tools) and management practices (e.g., canopy management and training systems, irrigation, water use efficiency, fertilizer) that can be used to improve labour and operational efficiencies in tree fruit, berries and grapes?** **Note: Proposals must include a Value Assessment Plan.**	The Ontario fruit industry is very reliant on manual labour. The COVID outbreak has made it clear that tree fruit and berry growers need to look at options for reducing their reliance on manual labour. Improved processes/systems/technologies 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 and monitoring and harvest practices. These new technologies need to be tested for their applicability to other production systems. In berry crops specifically, ultraviolet light (UVC) technology and robots for pest management, drones for monitoring and beneficial release, and robotic harvesters should be investigated. For tree fruit, technology that automates yield and fruit size data will help optimize labour and promote planning, marketability and sales. An essential component in improving labour efficiency and mechanizing orchards is to have orchard/vineyard systems that are designed to accommodate new technologies.	Develop and validate new technology that will help reduce labour costs and improves efficiency.	2020.034

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Innovative/Disruptive Technology Development	**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.**	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.	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.	2020.091
Innovative/Disruptive Technology Development	**What new tools and techniques can be developed to improve production and reduce energy and labour requirements in specialty crops (e.g., a litmus test to detect maple buddy sap before it's made into syrup, sap testing for nitrogen nitrate content used to adjust in-season nitrogen rates (e.g., in hops), adding ash to calcium-deficient maple sugar bushes)?** **Note: Proposals must include a Value Assessment Plan.**	Specialty crops often have relatively few growers who lack the funds to invest in innovative technologies that could make or break their fledgling industries. However, there are occasional opportunities to develop these tools and techniques that growers require the means to take advantage of. For example, a significant amount of maple syrup is wasted annually due to a phenomenon called buddy syrup, made using end-of-season maple sap that only develops off-flavours after boiling. Researchers are on the cusp of developing litmus strips that can quickly and easily detect buddy sap. This tool could result in significant time, labour, and fuel savings for producers, or prevent them from stopping production too early.	Novel technologies and techniques that may significantly improve production and efficiency in various specialty crops.	2021.036

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Innovative/Disruptive Technology Development	**With the adoption of smart farming technologies by a generation of predominantly older agricultural operators, what are the privacy and data sharing vulnerabilities/challenges that cut across societal, business, and legal areas?**	A better understanding of the vulnerabilities of Ontario's farming operations as a result of data breaches or access to proprietary information will enable the stronger protection of our food system.	A stronger understanding and a quantification of risks of Ontario's farming operations due to vulnerabilities from data sharing arrangements or privacy breaches.	2021.066
Innovative/Disruptive Technology Development	**What are the areas in which innovation and technology cannot replace human labour in the agri-food sector, including specific tasks and skills on the farm and in food processing plants, retail and distribution?**	An understanding of the agri-food sectors in which labour disruption is not anticipated will help inform labour policy and program initiatives and business supports.	Identification of agri-food subsectors where skills may be more in demand to support approaches to ensuring a skilled workforce is in place. Results would inform policy and program development and design respectively, to help support the development and/or maintaining of an appropriately skilled workforce.	2021.079
Input Use Efficiency	**How can supplemental lighting (overhead and inter-canopy lighting with different light recipes and spectra) be implemented in 1) vegetable propagation greenhouses to optimize seedling plant health, and 2) IPM and pest management strategies in greenhouses, warehouses, and vertical farms?** **Note: Proposals must include a Value Assessment Plan.**	There have been a number of research projects over the past few years studying the best ways to use supplemental lighting in vegetable production greenhouses. However, there is a need to better understand the best ways to use supplemental lighting in in vegetable propagation greenhouses and in integrated pest management (IPM) strategies.	Adoption of the most optimal lighting solutions that will allow for the production of high-quality vegetable transplants from propagation greenhouses for year-round production, and development of light recipes for plant protection to minimize damage by greenhouse vegetable pests and pathogens.	2019.088

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Input Use Efficiency	**What new or improved technologies and strategies can be used to provide controlled environment agriculture (greenhouse, warehouse, and vertical farms) with alternative ways of meeting energy and natural resources needs (electricity, water, heating, supplemental carbon dioxide and natural gas)? (ex. improved electricity generation and storage, improved water collection/production techniques)** **Note: Proposals must include a Value Assessment Plan.**	Controlled environment agriculture (greenhouses, warehouses, and vertical farms) acreage has been increasing at annual rate of 5-7% per year for the past 10 years, and this pace of expansion for these production systems is on track to meet or exceed that in the next 10 years. The growth of the greenhouse sector in particular has been concentrated in southwestern Ontario, and it has increased demand for electricity, water, and natural gas. This has put such a strain on municipal and provincial infrastructure in that region, such that Union Water implemented a water moratorium in 2021 on new greenhouse projects until updates to its aged unfractured were complete. New ways of reducing demand on the existing infrastructure for the controlled environment agriculture sector (electricity, water, and heating) are needed to sustain today's growth and to be competitive internationally in the future.	Technologies that will provide controlled environment agriculture with the resources it needs to grow, while reduce dependence on publicly/privately supplied (electricity grid, and water and natural gas supply).	2019.089

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Input Use Efficiency	**How do we maximize the economic return of growing industrial hemp for seed, fibre and/or flower (CBD extraction)? What genetic resources, agronomic, production and post-harvest practices are needed to optimize yield and product quality and maximize economic return.** **Note: Proposals must include a Value Assessment Plan.**	Industrial hemp can be legally grown in Canada for production of seed, fibre and cannabinoids like CBD. CBD extraction offers a new economic opportunity for the industrial hemp sector which continues to drive the expansion of outdoor production. The lack of Health Canada registered elite germplasm and scientifically validated production, post-harvest handling and processing information is a major roadblock to sector growth. Research is needed to develop new germplasm, to understand the best way to cultivate hemp for seed, fibre and flower (CBD), to harvest flower (for CDB) from large acreages and the logistics of supplying to licensed processors.	Research will provide validated information that OMAFRA staff can disseminate to internal and external stakeholders. UofG is developing capacity in cannabis/hemp research so this is an opportunity to leverage this capacity. Research will support help the sector to leverage this new economic opportunity for which Ontario has a first mover advantage. Currently the ability of Ontario hemp growers to competitively and economically produce flower are limited by a lack of Health Canada approved high CBD hemp cultivars. This research will allow development of these cultivars, thereby allowing Ontario growers to compete with other jurisdictions through the production of CBD rich oils and germplasm that can be sold globally.	2019.090
Input Use Efficiency	**What production practices and management recommendations can be developed to improve the yields, berry quality, season extension and competitiveness of strawberries and raspberries produced in soilless/substrate culture?**	New knowledge and information are required for these new production systems including research on protected culture, establishment, fertility and water requirements, harvesting methods and post harvest handling and storage in soilless berry production.	Research outcomes will include best management practices in producing strawberries and raspberries in a soilless system including fertility, irrigation, substrate choice, and protected culture.	2020.035

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Input Use Efficiency	**What are the optimal 4R practices (right source, rate, time and place) for application of nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) (from fertilizer or manure) to field crops to maximize economic crop response and minimize environmental losses? Top areas of interest include:** **- the likelihood (general risk, relative loss) of nitrogen loss for a given nitrogen application (product/timing/placement/use of inhibitors), soil type (texture, drainage), and the weather conditions since application? Where the nutrient is an organic amendment/manure, the product pH must be considered.** **- in-season loss risk estimates from volatilization, denitrification and/or leaching of pre-plant applications** **- optimal in-crop nutrient application practices (fertilizer or organic amendments)**	There is a lack of information on the effects of pre-plant and in-season nutrient (e.g., fertilizers, organic amendments) practices on N and P losses, N and P use efficiency and crop yields. Producers are encouraged to follow 4R practices, but more data is required to better understand and communicate these best management practices (BMPs).	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.	2020.042

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Input Use Efficiency	**What are the best tillage practices to optimize crop production, profitability and sustainable soil functioning (e.g., soil structure stability, erosion resistance, water dynamics) while minimizing nutrient losses?** **-comparisons of modern (e.g., strip-till, high speed disk, vertical tillage, bio-strips) and traditional tillage equipment** **-considering tillage timing, intensity, tillage depth, equipment setup and speed** **-across soil types, soil conditions, and across the crop rotation/multiple years** **-including livestock operations with manure in the system**	There is a need to provide more specific recommendations that balance the objectives of soil warming, drying, residue management, soil health, water quality (runoff/leaching) and crop response to tillage. There is limited research on comparisons of tillage equipment as it pertains to response of specific crops various tillage practices, soil health impacts, and trade-offs of crop vigour or yield vs soil function.	Required amounts of tillage and nutrients are optimized for crop production, and opportunities to reduce tillage are identified where tillage would provide little benefit.	2020.043

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
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 underestimated 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. Manure sensors are relatively new to North America and are starting to appear in Ontario. Currently the technology only works for liquid manure. It is very important to understand the relationship of manure nutrient testing from labs compared to nutrient sensing, validate the sensing algorithms, and evaluate the accuracy and consistency of all nutrients as they are applied. For example, setting the sensor equipment to apply for nitrogen (N) rate (which may be total N or ammonium N, and may not always be clear) will often result in over-application of phosphorus (P). Understanding how manure sensor equipment calibrates nutrients compared to lab analysis is also important for nutrient management regulatory plans and non-agricultural source materials (NASM) plans, where maximum rates, especially for phosphorus are regulated.	Improved nutrient use efficiency and application uniformity from use of organic amendments 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.	2020.044

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Labour Access/Efficiencies	**Pandemic responses, availability of Temporary Foreign Workers (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.	2020.026

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Labour Access/Efficiencies	**What are available cost-efficient manual labour-saving technologies (e.g., automation or other) for the agri-food sector which have been successful adopted or can be successfully adopted to reduce manual labour shortages (e.g., fruit and vegetable picking, processing of animals in meat facilities)? How does this technology currently compare to manual labour productivity? What is the cost/benefit of adopting such technology?**	Labour shortages are expected to be an ongoing issue in the agri-food sector for years to come. New technology is evolving to address agri-food manual labour shortages. There is a lack of Ontario data on what technologies are available/are being adopted, what the criteria are to purchase/adopt new technologies (e.g., concerns, risks, return on investment (ROI), technical staff needed, farmer/food processer socio-demographic characteristics) and what policies or programs will accelerate/expand the adoption of efficient manual labour saving technologies in Ontario's agri-food sector.	Results from this research could: 1. Quantify the rate of adoption of labor-saving technologies in Ontario's agri-food sector (horticulture, meat processing, food processing) by North American Industry Classification System (NAICS) code. 2. Perform a comparative study of automation technology in the field crops (such as corn and soybean versus the horticultural sector to test the hypothesis that automation is more prevalent for these crops (corn and soybean) than any horticultural crop in Ontario and the conditions (e.g., Farm Implements Act, Grains Act) that induced this adoption over time. Do a similar such study for the meat processing/food processing sub-sector. 3. Socio-demographic characteristics of farmers/meat processors/food processors adopting technologies faster than others. 4. The ultimate objective would be to understand the root causes of technology adoption rates (horticulture, meat processing, food processing) so that OMAFRA and its partners are able to activate the proper policy and industry levers to affect the desired agreed upon change. 5. Identify which labour-saving technologies are the most suitable to encourage Ontario's agri-food sector to explore and consider for adoption.	2021.006

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Labour Access/Efficiencies	**What labour is needed to meet workforce demands in agri-food? Supply-Side Labour Needs Assessment: Conduct labour force study and literature review with external organizations and partners resulting in report that includes job task analyses listing the skills, knowledge and credentials required of common agri-food jobs and identify skills, knowledge and abilities (common skills matrix) needed for the sector, and any specialized skill sets for sub-sectors within agri-food sector. Identify recruitment, orientation and training options already available (e.g., colleges, private career colleges, etc.), and map gaps and opportunities (e.g., micro-credentials). Document recruitment and retention gaps in the agri-food sector.**	Identification of required skills, knowledge and abilities will ensure targeted investment into specific sector-related training programs based on employer needs. Further, mapping effective recruitment and retention strategies will support farm labour management at both micro (farm or food processor) and macro levels in the province as well as meeting employer needs for trained workers. A skills matrix will inform the development of training programs offered by external institutions. The study will identify working conditions that support worker retention that will lead to promotion pathways within agri-food businesses. 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 emerging technologies in advanced manufacturing.	Comprehensive report on labour supply and demands in agri-food system. Identification of labour recruitment and training pathways to meet immediate and future labour needs. Further, there needs to be 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.	2021.075

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Labour Access/Efficiencies	**What pathways are currently available or needed to funnel workers into the sector? Fill Agri-Food Labour Gaps: Use the labour force study report of training needs and required core skills to inform the development of new training programs, apprenticeships or specialized micro-credentials programs in partnership with external training organizations, e.g., colleges, private career colleges, etc. Additionally, map out potential pathways for workers to access jobs and careers in agri-food businesses (processing and producers) that will aid with recruitment and retention of workers. Research should include efforts supported by MLTSD's Employment Ontario funded agencies to support recruitment and job placements with employer incentives.**	It is important to understand current pathways into the sector and how those can be enhanced to encourage larger numbers of workers to fill job gaps and to replace aging workforce. As well, it is valuable to identify training partners who will support pathways into the sector including short-term, job-specific micro-credential programs. The proposed research will directly benefit agri-food businesses as well as job seekers who may not have considered the sector as a career path. It will document effective strategies and potential partnerships between training institutions and employers. It will provide information to leverage MLTSD programs that support employers by supporting their recruitment processes, engage in job placements with potential workers and access to employer incentives.	A realistic snapshot of pathways (existing and potential ones) will target funding and supports to employers within agri-food that are in most need of workers. The desired outcomes include understanding the existing programs and supports (as well as gaps) in place to attract workers into the industry. The research report will positively impact the capacity of agri-food business and their potential productivity. At an individual job seeker level, the project will increase efficiency of training and recruitment pathways to access long-term employment in the sector as well as potential internal promotions. Results could inform further policy and program development beyond OMAFRA, including MLTSD.	2021.076

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Performance Measurement	**How can genetic and genomic selection increase production efficiency, environmental sustainability and animal health and welfare in Ontario livestock sectors? What are the barriers to on-farm data collection, participation in genetic improvement programs, and implementation of genomic selection in some Ontario livestock sectors (e.g., sheep, goat, beef)? How can "-omics" technologies (e.g., genomics, transcriptomics, metagenomics, proteomics) be leveraged to accelerate the rate of genetic improvement for difficult and/or expensive to measure traits (e.g., meat quality, milk composition, feed efficiency, disease and parasite resistance, lameness, mortality, longevity)?**	Genetic and genomic selection has been shown to rapidly accelerate genetic progress for countless traits in many livestock species, especially traits that are difficult and/or expensive to measure (e.g., meat quality, milk composition, feed efficiency, disease and parasite resistance, longevity, lameness). However, adoption of this technology remains limited in Ontario's sheep, goat and beef sectors. The successful implementation of genomic selection requires the availability of phenotypes for the traits of interest and development of genomic reference populations. Research is needed to determine the feasibility of genomic selection in these sectors for specific traits of economic, environmental, and/or animal health and welfare importance. Additionally, the existing barriers to phenotype recording and participation in genetic improvement programs should be explored for the benefit of the sectors as a whole. Traits including, meat quality, mortality, disease resistance, parasite resistance, milk quality and composition, and lameness were identified as key research areas by Ontario's small ruminant sectors. Genetic and genomic selection have been successfully applied to improve these traits in various livestock sectors around the world but need to be validated for use in Ontario.	This research could lead to 1) Implementation of genomic selection to accelerate genetic improvement for novel traits of economic, environmental or animal health and welfare importance in Ontario livestock sectors (e.g., sheep, goat, beef). 2) Identification of the barriers to phenotype recording, participation in genetic improvement programs and genomic selection in Ontario's, sheep, goat or beef sectors and development of tools and strategies to reduce these barriers.	2021.010

Innovative Products and Product Improvements

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Innovative/Disruptive Technology Development	**What new automation tools and techniques can be developed to improve production efficiency and reduce energy, labour, and pesticide use, and improve plant health decision-making and pest detection in greenhouse, warehouse, and vertical farm production of edibles (vegetables and fruits), ornamentals (flowers, landscape), and cannabis? (e.g., autonomous growing, sensor technology for climate and irrigation, packaging alternatives, vision systems and scouting software for integrated pest management (IPM), etc.)**	Greenhouse, warehouse, and vertical farm production is intensive, and often integrates tools and technology to make it more efficient. Technology that can improve production, energy or labour efficiency is needed to keep the sector competitive in domestic and international markets. On farm diagnostic tools and techniques are needed to improve the effectiveness of IPM programs. More efficient IPM will improve pest detection and control outcomes (e.g., finding pests at lower levels, using fewer biocontrol agents/pesticides due to earlier detection). The sector is a strong adapter to emerging technology, and options for greenhouses, warehouses and vertical farms 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 producers.	Cost-effective and innovative technologies that improve labour, energy, production, and pesticide efficiency. Outcomes would include efficiency/savings reports highlighting improvements to pest detection and outcomes; reports of reduced pesticide use due to better management and planning of IPM programs through data analysis; best management practices (BMPs) on how automation best fits into a system wide IPM program. Technologies would have a commercialization potential to benefit the sector as a whole.	2020.050
Innovative/Disruptive Technology Development	**With the adoption of smart farming technologies by a generation of predominantly older agricultural operators, what are the privacy and data sharing vulnerabilities/challenges that cut across societal, business, and legal areas?**	A better understanding of the vulnerabilities of Ontario's farming operations as a result of data breaches or access to proprietary information will enable the stronger protection of our food system.	A stronger understanding and a quantification of risks of Ontario's farming operations due to vulnerabilities from data sharing arrangements or privacy breaches.	2021.024

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
New Product Development	**What is the accuracy of the carbon sequestration values currently used for Ontario in the HOLOS Green House Gas (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.	2019.056
New Product Development	**How can a new cultivar of apple, tender fruit or grape cultivar be developed so that they are: 1) suitable for Ontario's climate, 2) fit current and emerging consumer preferences 3) disease tolerant?** **Note: Proposals must include a Value Assessment Plan.**	Consumer preferences for different tree fruit and grape cultivars change over time which is influenced by a changing age demographic and immigration. Having a deep understanding of which traits (flavour, texture, sweetness) consumers prefer now or in the future can guide cultivar development in Ontario. At the same time, heavily marketed, new cultivars that are licensed to be exclusively grown and marketed by groups of growers are emerging in the market (i.e., Cosmic Crisp, SweeTango, Pink Lady) and can be hard to compete with. Ontario needs to be investing in new cultivar development suited to consumer preferences in order to be competitive with these emerging cultivars.	New cultivars bred and evaluated that are suitable for the Ontario climate and growing conditions, are resistant to pests and diseases, and meet consumer preferences.	2020.052

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
New Product Development	**What are the processes to profitably develop value-added products for locally grown hops, including extracts for brewing and natural health products?**	International hop markets are variable for raw products (e.g., leaf hops and pelletized hops). In the last 10 years, hop extracts have captured over 15% of all hop use in Canada at the expense of pelletized hops. Currently there are no known hop extracts being produced in Canada from Canadian grown hops. This growing opportunity could provide Ontario hop growers with new market opportunities to produce extracts from their raw product making it more shelf stable and increase quality and longevity of their products. Additionally, some Ontario growers are investigating the opportunity for hops in other ways including as natural health products. Further understanding of the value of hops for health purposes and the development of products for end users is needed.	Development of cost-effective resin extract processing facilities and the development of high quality, novel packaging for Ontario produced hop resins for brewers. Develop a better understanding of health-related uses for hops and shelf ready products/packaging for the consumer market.	2021.039
New Product Development	**How can agricultural biomass be converted into carbon neutral renewable natural gas and hydrogen-rich gas? What practical processes could accelerate the production of hydrogen from Ontario agricultural biomass and what are the possible storage options for the produced hydrogen?**	Carbon-negative bioproducts will directly contribute to Ontario's commitment to reduce greenhouse gas emissions and bioeconomy development.	The production of new renewable fuels (renewable natural gas (RNG), hydrogen), and valuable green chemicals from agri-food biomass will help the government to meet its net-zero emissions commitment. To provide Ontario farmers with the opportunity to participate in an emerging supply chain.	2021.040

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
New Product Development	**Investigate new feed ingredients for livestock including insect proteins and by-products or other non-registered feedstuffs**	Nutrition makes up the majority of input cost of all livestock production. Research into new, economically viable feed sources could reduce input cost for expensive constituents like energy and protein. There continues to be increased interest in insects as a potential ingredient as we see an increase of insect farming in North America. There is approval for some commodities to use specific insect-based feed in Canada, but it is not yet widespread.	New ingredients and feeding recommendations for novel ingredients. An economically viable source of feed for livestock.	2021.041
New Product Development	**Investigate adoptions to existing technologies, (i.e., handheld near infrared (NIR) devices, etc.), that will improve the uptake of forage testing and investigate the potential for new technologies.** **Note: Proposals must include a Value Assessment Plan.**	Maximizing the performance of livestock requires a knowledge of the quality of forage available to beef cattle. Knowledge of forage quality can only be achieved through forage testing. Forage testing rates in the Ontario beef sector remains stubbornly low, despite all the KTT provided with regard to the productive and economic benefit of forage testing. Research is required to address the reasons behind low forage testing rates. The development of new technologies to make forage testing easier to undertake, results easier to understand and implement at farm level is critical to improve this situation.	The development of new technologies that have the capacity to improve the rate of forage testing by the Ontario beef sector, which in turn will lead to improvements in animal performance and farm economic performance.	2021.042

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
New Product Development	**What products can be developed or refined to expand the use of the dairy ingredient known as solids-not-fat (SNF)?** **Note: Proposals must include a Value Assessment Plan.**	One of the challenges in the sector is the disequilibrium in the marketplace for butterfat versus protein and other solids (SNF, for solids non-fat). Growth has been fairly strong for dairy fat recently and that's outpaced growth for SNF. As a supply managed sector, there are export caps for what Canada can export in terms of skim milk powder etc., which has been an important outlet for SNF surpluses. That outlet shrunk with implementation of the latest CUSMA trade deal, so new uses for SNF would be a positive development.	The results of this research could provide new markets for SNF within Ontario and Canada.	2021.043

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Product Enhancement	**What agronomic/processing and innovative technology (e.g., biochemical, thermal, bioprocessing, nanotech, AI, blockchain) research is needed to drive the production and use of alternative crops (e.g., camelina, switchgrass, miscanthus, hemp, pennycress) as feedstocks (fibre, sugars, oils, chemicals etc.), for the manufacture of bioproducts?**	Over 42% of bioproduct manufacturers use agriculture biomass as a primary input. There is an increasing consumer demand for sustainable bio-based products that replace those made from petroleum, but development of this sector is hampered by a lack of research in the areas of agronomy, processing and product development. Development of a competitive and sustainable bioproducts sector will require the identification, production and supply of consistent, high-quality feedstocks for bioproducts manufacture. The development of alternative uses of fibre from agricultural biomass (e.g., perennial crops, crop residue, hemp) is needed. Identification of non-traditional oilseed crops that replace petroleum products with renewable, carbon neutral feedstocks is also needed to combat climate change. Globally, first generation biofuel industries are transitioning to biorefineries that efficiently utilize feedstock inputs and co-product streams to generate higher returns.	Use of agricultural waste materials and production of renewable, sustainable feedstocks for the bioproducts sector is important for reducing the impact of climate change.	2020.049

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Product Enhancement	**How can the use of teat sealants be optimized in different milking and management systems to reduce the need for pharmaceutical interventions such as antimicrobials while also preventing their introduction into milk and milking equipment?**	Dairy cattle are susceptible to new intramammary infections during the dry (non-lactating) period. To prevent mastitis from developing during the dry period, many producers use prophylactic treatment of an intramammary antibiotic (dry cow therapy) when drying cows off. Cattle naturally develop a keratin plug to protect the teat from the introduction of bacteria after milking ceases. However, the time to plug development varies between cows and some cows fail to develop a keratin plug at all. Internal teat sealants (ITS) are a class of non-antimicrobial products that mimic the action of the cow's natural keratin plug to close the teat canal, providing a physical barrier between the udder and the environment, and are an alternative prevention measure to or in addition to traditional antibiotic programs. Increasing adoption of selective dry cow therapy protocols by dairy producers may increase adoption of ITS. The approach to ITS removal from the udder after calving influences whether the ITS product enters milking equipment and saleable milk. Although not a food safety risk, the persistency of ITS residues in milk can interfere with milking equipment functionality and milk quality. Are current recommendations for ITS removal sufficient to avoid persistency of ITS residues in milk? How can the use of teat sealants be optimized in different milking and management systems to reduce the need for pharmaceutical interventions such as antimicrobials while also	The results of this research could help to determine best management practices and provide a new method of intramammary teat sealant to Ontario dairy farms. This could prevent equipment malfunctions and increase milk quality where residues may have been previously.	2021.037

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
		preventing their introduction into milk and milking equipment?		

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Product Enhancement	**Investigate origins of white striping/woody breast/deep muscle necrosis in broiler chickens.**	This is a genetic/metabolic issue because the birds are growing so fast that it causes striations in the muscle and sometimes, pockets of necrosis. It is being investigated in other jurisdictions, but processors here are trying to figure out causes and solutions in Ontario as it has different production/housing/feed than the southern US that leads to these unique challenges. Everything from production practices, feed, enrichment, ventilation, CO2/O2 levels in the barn etc., should be considered.	Evaluation of the causes and solutions in Ontario, accounting for Ontario production systems.	2021.038

Trade, Market and Targeted Sector Growth Opportunities

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Domestic Market Analysis	**How can we develop supply chains, value chains, and/or create new market opportunities for specialty crops (e.g., ginseng, industrial crops, specialty fruit, specialty vegetables, specialty grains, tree nuts, herbs, hops, biomass crops) in Ontario? (e.g., develop economic, trade, and marketing information).**	There is limited knowledge on developing new supply chains, value-added products, and economies of scale for specialty crops in Ontario. This information needs to be developed and/or adapted for use in creating new market opportunities for the province.	The development of market and supply/value chain information will allow Ontario growers to identify those specialty crops that represent the best diversification opportunities.	2021.061

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Domestic Market Analysis	**How can existing obstacles in marketing ornamental products directly to consumers through online and direct market sales be overcome?**	COVID-19 has heavily impacted the ornamental sector. Contracts have been decreased or cancelled outright, leaving millions of plants without a market. Growers, the majority of which typically wholesale, are bring forced to find new markets for their crops by connecting directly with consumers. Since growers are not used to this type of market, and we believe it could grow into a new stable market following the crisis, there is a need to investigate this new potential market for its value, buying potential and needs (crops, logistics, utilizing major online retailers such as Amazon etc.). Major challenges to achieving this goal are: 1) Inventory changes hourly, daily, and weekly 2) plants that are sold at independent garden centres do not have unique barcodes that would transfer easily to online inventory.	A better understanding of the production inventory database and its flexibility, the market, and its needs. This could be used by growers to target their points of sale, investments, and marketing strategies more effectively.	2021.062

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Domestic Market Analysis	**How can we increase market uptake and consumer education on how to use new crops (e.g., haskap)?**	Haskap is the largest specialty berry crop in Ontario by acreage and is one of the most widely grown specialty berry crops in Canada. It is native to Canada with a wide growing range, has high nutritional value, and can be used fresh, frozen, or processed. The most active breeding program for the crop is based at the University of Saskatchewan with the majority of research efforts focused on developing improved germplasm for commercial production and understanding the nutritional value of berries. Challenges in selling the crop include harvest timing (berry colour is a poor indicator of berry ripeness) along with name and use recognition by consumers. Similar to other new crops, consumer recognition and education are a challenge for marketing and selling products. Ideally this research would help better understand the supply chain, value-added opportunities, and how best to educate consumers on what the crop is, how it should taste, and how to incorporate it into regular culinary use.	Development of a sustainable supply chain, increased opportunities to market and sell the crop, and how to best educate consumers on name recognition, appropriate flavours, and use in culinary applications.	2021.063

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Domestic Market Analysis	**What are the direct shipping lanes between Ontario and North American market areas, including the carriers for those markets by mode (truck or rail) and class (dry van, refrigerated or less than truckload)**	Logistics capacity and driver availability in the USA has been constrained over the past year due to COVID, port backlogs and delays that absorb available logistics capacity, driver turnover rates as high as 100%, the growth of last mile logistics, reduced driver training and mandatory US substance abuse testing that is permanently removing 5% of US drivers per year. Logistics costs in the USA have increased significantly and shippers (exporters) are experiencing high rates of load rejection for long haul shipments. This makes new business difficult to establish and is a pressure on existing business.	Identify the leading logistics providers by lane (between Ontario and delivery points by market area) would provide a template for Ontario's exports to access markets based on proven and existing service providers. The project may support increased use of multimodal services within Canada which in turn would increase the cohort of Ontario-based drivers for US-bound shipments which cannot be as easily served by multimodal connections due to the lack of in-market border clearance facilities in Ontario for US and Mexico -bound shipments.	2021.065
Domestic Market Analysis	**What are the consumer expectations regarding ethically sourced/farmed, produced, and processed food including environmental impact, social responsibility, and ethical labour practices? Is the sector meeting those expectations?**	Maintaining and enhancing public trust is important. This includes responding to increased public interest in sustainable, socially responsible, and ethical food practices. Understanding consumer demand and how the sector is responding to that demand to inform business supports targeted to sector recovery and resiliency.	A realistic snapshot of consumer demand to support OMAFRA policy and program development. Results would inform further policy and program development.	2021.078

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Global Market Analysis	**The COVID-19 pandemic has shifted consumer preferences, increasing both the need to strengthen ties with existing trading partners and understand current consumer trends. Use of ecommerce for grocery retailers and food service businesses significantly increased during 2020 as a way to safely get food to consumers, accelerating trends that were expected to take place over 3-5 years in just 3-5 months. Experts agree that the trend will have strong staying power around the world in the recovery period and beyond.** **With the likely increased reliance on ecommerce, what are the opportunities and challenges for Ontario's agri-food exporters interested in using e-commerce channels in key mature markets that Ontario has strong trading relationships with (specifically, the U.K., Germany, the U.S., or Japan) in the next 2-5 years? Given that the majority of Ontario's agri-food exports are value-added goods, which subsectors of Ontario's value-added agri-food sector might be most compatible with ecommerce opportunities (i.e., among Ontario's top 1 HS6 code agri-food exports: baked goods, confectionary, food preparations, etc.)? What barriers face agri-food exporting companies (e.g., shipping costs, logistics, non-tariff barriers, etc.)? Research could choose to focus on food-specific e-commerce developments arising in any of the four specific markets**	A growing trend in key mature markets is increased e-commerce in agri-food, and this has significantly accelerated during the COVID-19 pandemic. The ministry doesn't have enough information on what the best opportunities in ecommerce for agri-food exporters in key mature markets are. It would be helpful to know what barriers Ontario agri-food companies are facing in using e-commerce to export their products outside of Ontario. Once more is known about the scope of those barriers (e.g., shipping costs, logistics, non-tariff barriers, consumer preferences, etc.), then OMAFRA will be able to better consider the capacity of the Ontario agri-food sector to possibly meet demands (e.g., large enough scale; right products; etc.).	Obtain a better understanding of the opportunities and challenges for Ontario's agri-food exporting sector in key mature markets to then inform a strategic approach to address those barriers and maximize opportunities. This research would help answer the question how to this avenue of market diversification should be a priority for OMAFRA.	2019.079

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
	(either the U.K., Germany, the U.S., or Japan), such as the recent expansion of ecommerce platforms in the EU, or unique food delivery services in either grocery retail or food service channels. Proposals should offer specific insights, strategies and information relating to identified platforms that would help Ontario's value-added food exporters develop their own exporting plans. Results should consider Ontario's top HS codes for agri-food exports.			
Global Market Analysis	**What are the international market opportunities (e.g., Asia) for specialty crops (e.g., ginseng) and what are the regulatory (e.g., CITES) and non-regulatory (e.g., pesticide residues) barriers/challenges with serving these markets?**	Direct access to large international markets for Ontario crops and animal products (e.g., ginseng market in China) is impeded by numerous barriers (e.g., DDT and other pesticide residues, medications, paperwork required for CITES for tourist markets). Analysis of current challenges and opportunities and identification of mitigation options could support the growth of new markets for Ontario agri-food products.	Better understanding and evidence to expose barriers / challenges to accessing targeted markets for Ontario's crops and animal products.	2019.092

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Global Market Analysis	**How has the Covid-19 pandemic affected consumer behaviour in Ontario's seven key international priority markets (i.e., the U.S., Mexico, Japan, China, U.K., Germany, the Netherlands) and how does that shift present opportunities for Ontario's agri-food exporters in the next 2-3 years? What are the challenges and how can they be addressed? Proposals could focus on just one of the seven markets, or a combination of multiple markets among the seven. Proposals could consider regional demographics, purchasing power, packaging and flavour preferences, etc. and should offer specific insights, strategies and information relating to identified platforms (e.g., practical approaches like ecommerce or curbside pick-up, etc.) that would help Ontario's value-added agri-food exporters develop their own exporting plans. The focus of the synthesis/research should be on value-added agri-food goods since the majority of Ontario's agri-food exports are value-added products.**	COVID-19 has dramatically affected the global food supply chain. Ontario's agri-food exporters would greatly benefit from timely and relevant insights on the new landscape of exporting - both in terms of challenges and opportunities. Comparisons to the circumstances before the pandemic could help companies better adapt and adjust to the changes in the agri-food supply chain, which would contribute to Ontario's economic performance.	Obtain timely information on how Ontario's agri-food exporters can best recover from the impacts of COVID-19.	2020.029

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Targeted Sector Growth	**What are the most promising economic end use market opportunities for biomass crops (switchgrass, miscanthus), hemp, crop and food processing residues and by-products and for potential industrial bioproducts manufacture and value chains best fits for Ontario?**	There is increasing interest in transitioning 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 and biomass, organic residues/food wastes and other bio-based by-products. For example, Michelin plans to reduce its industrial carbon footprint by 5% to 25 % 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.	This research results will provide evidence to support 1) growth of the agri-food sector in Ontario, 2) expansion of acreage of biomass crops and hemp in Ontario, 3) new market applications for biomass crops and hemp, 4) use of advanced materials and industrial bioproducts manufacture from biomass crop feedstocks and 5) new feedstock supply chains and integrated bioproduct value chains which best fits for Ontario.	2019.093

Strong Rural Communities

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Emergency Management	**What types of supports (e.g., counselling, etc.) or programs (e.g., business case development, mentoring, etc.) should be provided to agricultural operators who have experienced a catastrophic loss of their livestock operation due to African Swine Fever (ASF), barn fire or another catastrophic situation? In other words, what types of resources should be put into place to build resilience amongst farming operators facing catastrophic losses or changes?**	Mental health research is currently focused on preventing suicide and addressing depression in agricultural operators, with a general focus on alleviating occupational stressors. A current research gap in this area is how to better address mental health supports following a catastrophic event, e.g., ASF resulting in the total loss of an operation or as a result of a barn fire.	Stronger mental health outcomes and a contribution to the literature on which resources can contribute to a more resilient agricultural community	2021.003
Labour Access/Efficiencies	**What are the barriers and risks equity seeking populations (including women, people of colour, low income/precarious workers, etc) face with respect to entering and advancing the in agri-food workforce (farm, food processing, distribution and retail)? What best practices exist to address these risks and barriers?**	Issues with access to appropriately skilled workers and overall sufficient levels of labour, which were pre-existing challenges, were highlighted and exacerbated by COVID 19. Understanding the risks and barriers will allow Ontario to better support the agri-food sector and ensure healthy and safe work environments.	A comprehensive report on risks and barriers will help supports employers within agri-food that are in most need of workers. An understanding the existing barriers in place to attract workers into the industry and support workplace advancement. The research will contribute to positively impacting the capacity of agri-food business and their potential productivity. Results could inform further policy and program development.	2021.077
Labour Access/Efficiencies	**How can housing arrangements be improved to reflect the health and welfare needs of temporary foreign workers (TFWs)?**	There are several challenges with biosecurity, social interactions and environmental quality within different TFW housing options. The current availability and quality of housing options needs be assessed to develop new arrangements that	Outcomes will include knowledge regarding current housing systems and management practices, options for improved housing arrangements that support optimal health and welfare conditions for TFWs.	2021.083

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
		support optimal health and welfare conditions for workers.		
Rural Community Development	**What factors or barriers are hindering a stronger economic recovery in rural Ontario from the COVID-19 pandemic?**	The COVID-19 pandemic is having differing impacts on different industries and locations across Ontario. This research will help us better understand the economic recovery laggards including the potential barriers that may be limiting their recovery.	A better understanding of which industries and rural areas have been most impacted by the pandemic including potential reasons preventing a full economic recovery will be the outcome of this research	2021.070
Rural Community Development	**As the COVID-19 pandemic has strengthened the migration of urban dweller to rural and small towns across Ontario - what are the challenges and opportunities for rural communities?**	There is currently little research that has examined the impacts of this out-migration trend on key economic indicators including housing affordability, workforce attraction/retention, business development/growth, infrastructure renewal and health care costs in rural communities.	An outcome of the research will be a stronger understanding of the broader and long-term impacts of the migration to rural communities (heightened by the pandemic) including analysis on the continuation of this trend and the impact on rural communities.	2021.071
Rural Community Development	**Given the prevalence of working from home during the pandemic – is inadequate high-speed broadband deterring investment attraction and lowering real estate values in underserved rural areas?**	The COVID-19 pandemic has highlighted the digital divide in rural Ontario. By examining key economic data – this research will enable us to better understand the impact of broadband investments on real estate values and investment attraction decisions.	The research will contribute to a stronger understanding of the impacts of broadband investments as an economic driver in rural Ontario.	2021.072

APPENDIX: OMAFRA Research Questions

Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
Rural Community Development	**COVID-19 has highlighted the ongoing food insecurity challenges faced by Indigenous communities. While barriers to overcoming food insecurity are well known, an integrated Indigenous food security strategy for Ontario is needed. What are the elements of an integrated Indigenous food security strategy that can be adopted, locally, regionally and provincially?**	Food insecurity, lack of access to affordable healthy food and lack of food sovereignty in Indigenous communities, particularly in northern and remote communities, is a well-recognized issue of concern with multiple contributing factors that require collaborative problem-solving approaches. Interdisciplinary research focused on, but not limited to, infrastructure, economics, technology, agronomy, policy and human health are needed to meaningfully address this chronic challenge facing Ontario's indigenous communities.	This research can provides insights into shaping an integrated indigenous food security strategy that have many benefits including proving access to healthy food in indigenous communities including: improved health, increased economic development opportunities in food production, processing, niche market development and new transport technologies, community resilience and capacity.	2021.073
Rural Community Development	**What are the structural barriers (infrastructure, transportation, policy, lack of investment, etc.) limiting the development and expansion of Indigenous participation the agri-food economy?**	Indigenous partners continue to indicate that multiple structural factors are preventing their participation in the agri-food economy thereby limiting their economic development and exacerbating food insecurity, especially in Northern and remote communities.	This research can contribute to improved understanding of the barriers to Indigenous agri-food economic development and the development of novel strategies and approaches to address them.	2021.074
Rural Community Development	**How can rural communities attract, support and retain new community members (including new Canadians) that can help address rural workforce gaps and strengthen rural communities?**	While some rural areas have seen overall population growth in recent years, many rural communities struggle to maintain their populations due to issues such as youth out-migration, aging populations and declining birth rates. This research will provide insights to help communities identify the strategies and supports needed to attract newcomers (including new	Outcomes will include strategies for population attraction, retention and growth.	2021.084

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Research Focus Areas	Question	Rationale for Research and Benefit	Outcomes and Deliverables	RIB ID
		Canadians) based on local workforce needs and trends.		