OMAFRA Strategic Research Themes

Priorities for 2008-2012

OMAFRA – University of Guelph Partnership

Ontario Ministry of Agriculture Food & Rural Affairs

August 18, 2008

Table of Contents

OMAFRA RESEARCH PRIORITIES: INTRODUCTION

GENERAL CONTEXT

Under the Ontario Minsitry of Agriculture, Food and Rural Affairs (OMAFRA) and University of Guelph (UofG) Agreement of 2008, OMAFRA determines research themes to be addressed through the Research Program and establish a priority setting process, including the identification of long-term strategic areas of research and critical success factors for each research theme. During the summers of 2007 and 2008, OMAFRA in collaboration with UofG and sector experts (Expert Panels) engaged in a process that resulted in the preparation of this research priorities document titled "OMAFRA Strategic Research Themes: Priorities for 2008-2012".

The Expert Panel processes of 2007 and 2008 focused on the following seven research themes: Agriculture and Rural Policy; Bioeconomy – Industrial Uses; Emergency Management; Evironmental Sustainability[1]; Food For Health; Product Development and Enhancement through Value Chains; and, Production Systems.

Expert Panel reports are used to inform all research related activities at OMAFRA. Therefore, the final recommendations from each Expert Panel are the foundation of the research prioirites outlined in this document. The ministry also received input concerning priorities from the Agricultural Research Institute of Ontario (ARIO), from policy and program staff at several levels within the ministry and from stakeholder organizations. Under the OMAFRA/UofG Agreement, it is expected that, UofG will use these research priorities to lead the development of a strategic plan to administer OMAFRA funded research programs (identifying capacity and program options).

INTERPRETATION OF THIS DOCUMENT

The information in this document is organized in such a way as to provide at the outset of each thematic section the definition and context of the theme, as well its scope. Understanding the sections on priorities requires an understanding of the theme's background information. In some cases, the priorties within each theme are are outlined as general areas; in other cases, they are given as examples in a list which is not intended to be exhaustive. In all cases, it is understood that the research priorities within are flexible enough to be responsive to emerging issues, but specific enough to encourage a coordinated response to the ministry's information needs and provide practical support for policy and programs relating to the ministry's specific mandate.

[1] Priorities for the Environmental Sustainability theme were the only ones developed and communicated to UofG in 2007, but are included in this document to confirm ministry's priorities regarding this theme.

CONSIDERATIONS FOR STRATEGIC PLAN

The following points should be considered when developing options to address the priorities identified in this document:

- Several common needs were identified under all research themes: the need for baseline data, statistical research and longitudinal studies; sector and trend analysis; foresight and scenario analysis; and, policy or regulatory program evaluation. OMAFRA considers these needs as research priorities.

- There are many opportunities for collaboration and multi-disciplinary approaches in research areas that span two or more themes. OMAFRA encourages program flexibility to address these cases.

- Policy related research (not limited to rural policy or agricultural policy) should focus on research that examines the actual impacts of existing/past policy initiatives or the potential impacts of policy actions under consideration.

- Some critical success factors noted in theme areas could be a foundational type of research (i.e. inventory/synthesis research) and should be equally researched where appropriate. OMAFRA also recognizes the evaluation of research as a beneficial activity under the program.

The ministry envisions the annual revisiting of theme prioirites as is required under the OMAFRA/UofG Agreement. This should be regarded as an ongoing process which will incorporate stakeholder input and serve to recomfirm the importance of current priorities, refocus energy toward emerging priorities, and reassess short or medium term direction research themes.

AGRICULTURAL AND RURAL POLICY:

AGRICULTURAL POLICY

1: Description and Scope of this Theme

1.1 Theme Description

The Agricultural Policy theme encompasses policy issues relating to farming: government regulations and their impacts on farmers and rural communities, farm program analysis, farm management challenges, agricultural trade and marketing, agricultural business and finance, promotion of innovation, and agriculture in economic development.

- Agricultural policy is the process of assessing sectoral performance and provides the basis for correcting market failures, reacting to crisis issues, identifying policy alternatives including costs and benefits to all sectors of society, and to facilitate coordination, in an environment of interest groups politics. The focus of agricultural policy research is on identifying where markets fail and where coordination is required, and how corrective measures can be implemented.
- Impact of government actions on innovation, competitiveness and sustainability of the agri-food products sector.

1.2 Content Components of the Theme

The theme core components identified are **Innovation, Competitiveness**, and **Sustainability**.

- The Sustainability component is to be interpreted as inclusive of reactionary needs to emergency events.
- Sustainability relates to two areas of focus- human resources and environment/land use. Aspects of "Agricultural Landscape" are combined with Environmental to become an "Environmental/Land Use" sub component within the sustainability theme.
- Competitiveness includes policies that facilitate or hinder Ontario profitability.

2: Context and Background for this Theme

2.1 Key Assumptions

The assumptions listed below deal with inferences regarding Ontario-specific factors relevant to agriculture and food. Background items reflect important issues beyond the Ontario context.

- Agricultural policy research is conducted in support of OMAFRA policy development. Thus, OMAFRA needs policy research that addresses its policy objectives. The vision behind policy is most clearly described by the following, "Ontario's agri-food sector will be innovative, sustainable and provide opportunity for profit for all participants. We will be globally competitive and the supplier of choice by responding to consumer needs and contributing to provincial prosperity, the environment and the health of citizens".
- Ontario is a widely diverse agricultural region which is capable of the sustainable production of a broad range of farm products on its base of 5.38 million hectares.
- Ontario is centrally located geographically relative to agri-products markets in Canada and the Northeast US.
- Maintaining growth in productivity has been a struggle in Ontario agri-products.
- The median age of Ontario farmers has been increasing, and many are nearing retirement age. There has also been a broad decline in the number of farm operators in Ontario, and the human resource stock across the broader agri-products supply chain has lagged.
- Recruiting and retaining quality employees is an ongoing challenge in the agri-products sector, and competition for labour from other industries is intense.
- A diversity of marketing structures exists in Ontario and there is little consistency among them. The interests of supply managed industries, in terms of trade liberalization, are at odds with the freer market groups and most of the provincially regulated marketing groups. Trade policies which fully support one group's approach tend to diminish that of the others.
- Progress in trade liberalization is clearly beneficial to some segments of Ontario agri-products and is perceived as a threat to others. While the distributional issues are anticipated, it is assumed that liberalization would be a net benefit to Ontario.
- Governments and individual citizens in Ontario are becoming increasingly interested and concerned about the environment in agricultural areas and the impact of agricultural practices, and have demonstrated willingness to support initiatives to protect the rural environment.
- Farm profitability is an important objective of agricultural policy in Ontario.
- In Ontario and elsewhere, rural property rights issues and land use conflicts related to various government programs and policies are increasing. The rural issue overlaps with issues under the Expert Panel recommendations for rural policy research.

Background and Trends

- Trade liberalization is poised to continue its expansion in agri-products based on developing multilateral and bilateral agreements.
- Increased trade will be fueled by rapid economic growth and the emergence of a new middle class in developing countries.

- This is coincidental with steep inflation in energy prices, both in terms of energy consumed by devices and of energy contained in feedstuffs. As this has occurred, energy in feedstuff form has increased in price relative to protein feedstuffs.
- At the same time, consumer demands are segmenting across many different dimensions including price, convenience, environment/production practices, healthfulness, and natural/organic.
- Agricultural policy research is in flux, with changes in intellectual property rights, funding levels, transition to greater focus on private and public/private research, and very rapid dispersion driving change. Agricultural research is being done by an increasing number of institutions, requiring improved coordination.
- Awareness of food safety, zoonotic diseases, and the control of foreign animal and plant diseases is increasing. This creates a latent public health risk and risk in terms of agri-products sector liability from trade actions and product recalls. The ability to verify and certify product information is a critical means of product control, accessing markets, maintaining markets, and defending liability.
- Demographic changes are leading high-income countries toward an older profile, while less developed countries are relatively young. Aging consumers will be more focused on eating to attain health; this is also of interest in developing economies, but there will be relatively more interest in protein and carbohydrate to feed young populations.
- Governments are increasingly concerned about global warming, carbon emissions, and strategies for mitigation. Agriculture is a net CO_2 sink.
- Technology from research is being adopted at a rapid rate.
- Markets are increasing volatility and there are more and more value perception conflicts – economic assessment will help work out the conflict.

2.2 Opportunities

The range of issues to be addressed by agricultural policy decision makers is broader than it used to be. Policy makers once focused mainly on producer safety nets, trade and regulator issues; now they must also address food processing, consumer needs and expectations, and a range of societal concerns among others.

2.3 Issues and Barriers

- There is a need for comprehensive, quality data for economic research.
- There is a need for additional resources, especially human resources available to do the work.
- We must identify the audience for agricultural policy research in order for it to be relevant and for it to be implemented.
- Technology transfer from research is critical.

2.4 Enabling Components of the Theme

The following issues are important in allowing the core components to be successfully explored in research:

- The concept of an Ontario agri-products "Outlook" which places conditions in the sector in context. Rather than it being a forecasting effort (which would result in a standard outlook conference) the analysis should be based on alternative scenarios, with research determining what the implications would be. This scenario analysis would be foundational.
- Need for econometric or optimization models that can serve as a platform for targeted research projects – reference to the CRAM model at AAFC (tightly maintained) and a similar model at Food and Agricultural Policy Research Institute (FAPRI); these are very expensive to develop and to maintain.
    - Such models allow scenario analysis
    - There is a need for such a tool in Ontario/Canada outside AAFC

2.5 Dependencies and Linkages with the Theme

A number of issues raised under this theme are also relevant to other themes; e.g., environmental issues are related to the environmental sustainability theme, and food policy has linkages to the food for health theme, the rural policy theme or the emergency management theme.

In addition:

- There is a critical need for quality and timely data
- Linkages to technology transfer are vital
- A "systems" approach to policy research is necessary
- Better interaction of the research community with the producer/industry community would be beneficial in recognizing the increasing changeability of the farm community.

3: Research Areas and Priorities for the Theme

3.1 Description of Research Areas

A Innovation: How do government policies affect the ability of the agricultural sector to be innovative?

The innovation core area relates to how the agri-products sector uses resources for the purpose of discovery and knowledge creation. This is to be interpreted in its broadest sense, from policy relating to agricultural research to the impact of policy on the ability of the sector to be "innovative". Within this core are the following examples of research areas:

- Assisting evolution and targeting farm and food product marketing.
- Policies to facilitate producer adjustment and transition.

- Agricultural research policy and technology adoption. What do producers need to overcome barriers and take advantage of opportunities in technology adoption along the innovation continuum?
- Policies on non-food uses of farm products.
- Entrepreneurship: What are the critical factors which support and lead to the emergence of entrepreneurial behaviour?
- *Ex ante* evaluation of new technology.
- Role and net benefit of technology in securing a workforce in agri-products.

Top priorities: Policies to facilitate producer adjustment and transition, agricultural policy research and technology adoption, and *ex ante* evaluation of new technology.

B Competitiveness: How do government policies affect the ability of the agri-food sector to compete regionally, nationally and globally?

The competitiveness core area relates to the sustainability within which the sector can maintain market share, and the extent to which it can compete for resources with other jurisdictions and other segments of the domestic economy. Within this core are the following research areas:

- Regulatory impact in agri-products.
- Impacts and opportunities under trade agreements.
- Impact of risk mitigation and program design in the context of Ontario's competitive environment.
- Impact of financial and macro market conditions.
- Policy influences on supply chain profitability, organization, and cost competitiveness.
- Policy consistency with consumer perceptions and needs.
- Impact of animal and plant health policy on human health and farm competitiveness.
- Impact of North American market integration and broader globalization.
- Insights into the scale of production, from bulk production to local food production. And what are the implications for sustainability?
- The relationship between incentives/disincentives and the rate/appetite for change (i.e. farmers are reluctant to make changes if they are compensated for losses sustained in the production of their commodity).

Top priorities: Impacts and opportunities under trade agreements, policy influences on supply chain profitability, organization, and cost competitiveness, and Impact of financial and macro market conditions.

C Sustainability: How do government policies affect the ability of the agri-food sector to be sustainable in a time of transition with a changing demographic, social and cultural profile?

The sustainability core area considers carrying capacity in terms of human resources, rural landscape resources, and environment. It relates to the capacity of natural and human systems to support activity and growth in the agri-products sector. It is understood that in order for the sector to be sustainable, it must be innovative and competitive.

a. Social
   - Integration of agricultural policy with human health policy.
   - Sources, needs, exit, recruitment and securing the workforce in agri-products.
   - Agri-products and agricultural research policy for a diverse agri-products sector.

b. Environmental/Land Use
   - Costs and benefits to industry and/or taxpayers of existing and proposed environmental, land resource, and land use regulations.
   - Assessing impact of agricultural policy on ecology/the environment.
   - Policy alternatives for energy conservation, climate change, and environment.
   - How can the concept of ecological goods and services be reflected in public policy in such a ways as to contribute to the sustainability of the agri-food sector?

Top priorities: Impacts, costs and benefits to industry and/or taxpayers of existing and proposed environmental, land resource, and land use regulations; assessing impact of agricultural policy on ecology/the environment; policy alternatives for energy conservation; climate change and environment.

4: Critical Success Factors

4.1 Description

The following factors are critical to the success of research areas identified above:

- Agricultural policy research needs to be coordinated with policy development to avoid *bad* policies.
- Agricultural policy research needs to be rooted in robust economic models.
- Need for improved institutional structure and resource support.
- Availability of timely and relevant data is critical.
- Need to better understand the audience for agricultural policy research. The results of research need to be ccommunicated to users and taxpayers, with the rate of return on research measured and communicated.
- The beneficiaries for agricultural policy research tend to be more dispersed than other types of research. Alternatively, needed research is controversial or politically sensitive. As a result, matching funds are difficult to get for agricultural policy research. May want to consider lower matching requirements.
- Need for provincial governments to communicate with one another about cooperation/coordination/collaboration across research institutions (as pressure is already on institutions to do so).

AGRICULTURAL AND RURAL POLICY:

RURAL POLICY

1: Description and Scope of this Theme

1.1 The Approach

Rural Policy is integrated with agricultural policy. However, this should NOT lead to agricultural dominance of the policy sector as agriculture and food are seen as components of rural development. This theme is more appropriately viewed as 'rural development' policy.

Rural Policy research would benefit from setting out three to four over-arching, strategic components as a guide for the next five years. This strategic approach will encourage linkages with other themes areas such as Agriculture Policy and the Bio-economy/Industrial Uses theme, as well as collaborative efforts with researchers at other institutions.

1.2 Theme Description

The Rural Policy research theme focuses on the nature of the changes, challenges and opportunities facing rural Ontario including the impact of current policies and programs. The strategic priority components are; climate change, regional development, rural infrastructure, transportation, and rural labour markets.

Top Priorities:

- Climate Change
- Regional Development

Medium Priorities:

- Rural Infrastructure and Transportation
- Rural Labour Markets

Foundational, base-line data generation is vitally important to OMAFRA. Meta-analysis could also provide a critical base of information for policy development. OMAFRA requires statistical evidence of impact to help influence the policy development in other ministries. Assessments of the impact of government policies, including those policies that affect local government and business are critical for sound policy development.

2: Context and Background for this Theme

2.1 Context and Background

Thriving rural Ontario, agriculture, and food sectors… OMAFRA's Vision

Rural Ontario is a significant contributor to Ontario's economy as well as a provider of social and environmental resources to rural residents and their urban neighbors. Traditionally, resource-based industries, agriculture, forestry and mining, dominated the economy and shaped the lives of rural residents. Today, a diversified economy has emerged. In addition to resource-based industries, manufacturing and services are no the main sources of employment in rural parts of the province.

Like the rest of the world, rural Ontario is experiencing significant changes to the way it generates prosperity and the rural way of life. Altogether, the traditional sectors and the new cross-sector dynamics produce a complex picture of contemporary rural Ontario: one that challenges policy makers and planners to understand and to sustain. For example, the new dynamic between agriculture and rural development represents a convergence within this complexity*. 'Rural' is the dominant context in which agriculture, along with other economic activities takes place.*

Rapid changes in agriculture and the emergence of "new" agriculture; bio-economy, food for health, and the local food movement are having a significant impact on the sector as well as on rural communities. This represents a major challenge for policy development that will require a comprehensive, integrated *(rural, agricultural and urban)* and flexible formation of policy priorities.

The rural regions of Ontario and the communities within them are diverse. Given that there are many 'rurals' across Ontario, the policy response requires recognition not only of the complexities described above but the need for 'place-based' approaches. Differences in population density and travel distances for work and services demand new adaptable policy and program delivery approaches. This represents an opportunity in rural development. This is especially the case in northern Ontario where resource dependent communities and remote Aboriginal communities present special challenges. Thus new rural development requires new and creative forms of policy research.

For policy development purposes, three types of policy research will be significant:

Big Picture Research

This involves the construction of ideas about 'rural' and its place in the world. Big picture research predicts what is likely to happen with national, inter-regional or global trends and how the rural world works in relation to these trends.

Impact Research

This type of research measures the impact of existing rural policies or policy and programs that affect rural areas. It also compares the delivery of policy and programs in other jurisdictions for potential adaptation to Ontario conditions.

Emerging Issues Research

This research examines new issues that are emerging in rural areas. The policy aspect of such research focuses on how the state and/or civil society can respond.

2.2 Key Trends

- Urbanization will continue. Rural-urban systems will remain a prominent part of rural development and should be studied in ways that consider rural assets to be as valuable as urban demands
- The influences of urban centres on rural regions are not clear.
- Economic development will remain a provincial and national priority.
- The impacts of provincial and federal policies on rural municipalities are not fully known. Provincial policies such as the "Places to Grow", "Greenbelt" and "Species at Risk" legislation have affected the economic future of many small rural municipalities both in terms of restricting growth and in increasing the costs to the municipality and the environment when too much growth is encouraged. The impact of these policies should be assessed prior to and post implementation.
- The environment will remain a challenge for policy makers at all levels and the issues brought forward will be complex in nature. Of related equal importance is the issue of climate change and the impact that this condition will have on current rural regions and livelihoods across Ontario.
- Energy production and consumption will remain a key factor in rural development for the next decade. Rising petroleum prices represent both a barrier and an opportunity to rural development. New, innovative transportation models offer a significant area for rural policy research.
- While the future role of small and medium size enterprises is uncertain, they are likely to play an important role in sustaining economic growth.
- There is increasing importance given to immigration attraction and retention in rural areas, but it is not clear what policy tools or approaches would best promote the objective.
- For all the above assumptions the question of 'subsidiarityy' (what is the lowest level of government to deal with the issue) has not been fully examined in the 'rural' context. Issues of new governance revolve around the question of scale, regionalization and place-based program delivery in the Ontario context.

2.3 Other Trends

- The current state of high commodity prices is impacting the agriculture sector and the surrounding rural communities and continues to add uncertainty to the development of short and long term policy approaches.
- The aging infrastructure across Ontario and the increasing cost of maintenance and replacement will continue to challenge governments at all levels to allocate scarce resources in an equitable manner.

- The US-Canada border traffic continues to decline with the related impact on tourism opportunities for both urban and rural Ontario.
- The Aboriginal population in both urban and rural areas is increasing. The focus of national and provincial aboriginal affairs is one of relationship building.

2.4 Opportunities

Many of the assets of rural Ontario are being re-valued as commodities (e.g. ground water taking) and this will provide greater opportunities to focus policy research on rural sectors and on place-based (community) assets of the Province. Climate change research for example will force researchers to design integrated projects involving university consortiums working across jurisdictions and disciplines that open up new avenues of research. Complex dynamic systems research may have much to offer in this regard as it joins human systems with ecological dynamics. Such research could well link rural policy with emergency management for example.

2.5 Issues and Barriers

Limited funds and capacity will severely limit the effectiveness of rural policy research in Ontario. There are very few publicly accessible data sources available to researchers in Ontario.

3: Research Areas and Priorities for this Theme

3.1 The Approach

The following broad research components will allow several sub-themes and issues to be addressed and many synergies to occur over the long term. Policy research supplies 'policy intelligence' on strategic topics to support OMAFRA policy and programming as well as rural policy 'proofing' among groups of Ontario ministries.

3.2 Description of Research Areas

A Climate Change

- This research component is of international, national and provincial importance. It has clear implications for rural municipalities also. There are a growing number of studies globally on rural community responses to the effects of climate change, many of them in the agricultural community domain (Arkleton Trust, 2008). The objectives are to explore rural communities' particular challenges, identify best practices in community response, and consider how best to replicate these in other jurisdictions.
- Climate change contains mainly environmental issues as the immediate focus of interest, but has implications for human impact and agency. One could apply climate change scenarios to almost everything, including sectors, and places. Many ecologists have argued that making sense of climate change requires working at the regional scale, ideally at the 'watershed' scale of analysis.
- Climate change has significant implications for policy as it challenges all the intents and practices of policy and programming. It demands clarity on what is the public good. It

requires science to be interpreted in the human interest. It will require bold and imaginative leadership at all levels if civil society actions as well as the traditional policy instruments of regulation and incentives are to 'make a difference' in public choice.

The component is divided into climate change mitigation (prevention) and climate change adaptation (adjustment).

Climate Change Mitigation: Examples of research areas

- Local governance models and municipal infrastructure may limit capacity to mitigate the effects of climate change. How can this be overcome?
- Carbon tax…what is the rural-urban impact differential? Will rural be disadvantaged?
- Energy conservation - what opportunities are there for rural?
- Energy production – convergence to green energy. What can be done at the enterprise/community/household level? Is this part of economic diversification?
- Grid access. What would rural policy look like if farms and rural businesses were able to generate green energy?
- Fossil fuel replacement – impacts on rural economies.

Climate Change Adaptation: Examples of research areas

- Reduced availability of water
- Water pricing
- Water conservation
- Fiscal and social capacity for adaptation in rural communities and how this can be mitigated
- Assess impact on rural industries
- Impact on rural tourism
- Impact of invasive species

Such research will require information on micro-climate change and will invite new technologies to be developed in the future.

These examples of research questions illustrate the 'bundle' of topics which could be researched under the climate change component. They are mainly technocratic in this list and many more prevail on the human and institutional impact side of the equation. Adapting to climate change will affect all aspects of rural life.

B Regional Development

- In the Ontario context, the term 'regional development' has a number of definitions and understandings. While various models exist world-wide and numerous research studies have focused on the nature, drivers and outcomes of regional approaches to economic development there is currently no formalized approach in Ontario. In Canada, only in the province of Quebec are regional jurisdictions actively engaged as integrators for both rural and urban economic development as well as environmental and social programming.
- However, a number of initiatives and policies are focusing on rural Ontario in its regional context. The growth of regionally-relevant legislation e.g. Greenbelt is creating impacts across municipal boundaries as are the Growth Plans. The Lake Simcoe Act also provides

an example of regionally-focussed legislation that is place-based. Federal investments through the Community Futures Development Corporations and the Eastern Ontario Economic Development Fund have also promoted regional economic development approaches.

- Little is known about the impact of regional policies and program approaches on rural economies in Ontario. Literature is available on regional development initiatives in the UK, the EU, and the USA. These studies mainly focus on mandates, governance models, financing methods, planning strategies and outcomes. This body of research is worthy of analysis to discern lessons learned and their applicability to rural Ontario. Of critical importance are the development of baseline measures and the creation of diagnostics to assess economic sustainability in a variety of rural Ontario regions.
- Need to understand diversity of rural economies in the context of multiple "rurals" and capacities.
- New governance models including collaborative public/private/volunteer sector/NGO's – co-governance models are required to address the management challenges and the complexities in a regional approach. This should allow for a discussion of the appropriate level for decision-making.
- Any examination of regional development models should also consider both the economic and social aspects of rural development.

The regional development research area provides an opportunity to conduct impact analysis and new policy direction analysis.

Impact Analysis

- Rural/regional innovation and competitiveness – comparative analysis.
- The economic, human and social aspects of regional development.
- Evaluation of current policy and programs - accomplishment of expected outcomes and impact on regional economies e.g. telehealth.

New Policy Direction

- The development of an analytical framework for regional economies that considers all of the physical, human, fiscal, social, natural and cultural capital.
- Development of models for regional collaboration including new governance models.
- Assessment of the various regional models that have emerged over the past fifty years to gain insight into mobility patterns – 'how people move about to sustain livelihoods'.

C Rural Infrastructure

Transportation Infrastructure: "what is the impact of public transportation issues on a sustainable rural Ontario?" Some of the impetus for this crucial topic derives from the recently published Senate report on Rural Poverty, (2008) in which the lack of public transportation in rural areas appears as a crucial contributor to the many traps that the poor (however defined) find themselves in. Lack of public transportation in rural Canada was referenced in the Senate report 11 times:

- Environmental impacts of continued (conventional) automotive transport dependency;
- Impact of increased energy costs;
- Impact on labor supply to rural labour markets, especially manufacturing;
- Impact on rural, small town and remote area 'quality of life';
- Assessment of 'city bus extension into rural areas' models;
- Assessment of independent local bus system models;
- Municipal cooperation models;
- Collaboration among sectors and agencies;
- Differential impacts of where such models will work well; and
- Impact of accessing normal life for the (working) poor.

Municipal Service Delivery:

- The deterioration of roads and bridges in some rural and remote areas has seriously hampered rural development and will continue to do so unless vigorous funding programs are sustained.
- Gas tax contributions to rural constituents and regional scales of infrastructure support might make more financial sense in rural and remote areas.
- Infrastructure development is important for rural construction businesses in the creation of jobs.
- Water, waste water and solid waste management infrastructure development is critical in building a secure and healthy system of municipal services and creating an attractive climate for economic investment.
- Adequate telecommunications infrastructure and broadband access is vital to the new marketing and business management realities for small businesses, 'upskilling' and education opportunities via distance education programs, and attraction and retention of investors and professionals to rural areas.
- Expand research areas to include brownfields redevelopment and local cultural and recreational infrastructure.

D Rural Labour Force

The availability of a well-trained and educated labour force in rural Ontario is a critical component of attracting and retaining businesses and industries in rural Ontario. Ontario's lead ministry, Ministry of Colleges, Training and Universities (MTCU), has not adopted a regional approach to labour force development.

The following trends require further exploration regarding the impact of a changing demographic profile on labour needs in rural Ontario:

- An aging workforce and the out-migration of youth lead to labour shortfalls. In the interest of innovation and competitiveness, firms are moving in the direction of making capital investments which minimize their labour needs.

- Greater integration of Aboriginal people and youth into the labour market.
- Potential of new immigrants to meet rural Ontario workforce needs.
- The demographics of rural labour markets are changing with the emergence of non-traditional agricultural entrepreneurs, the migration of urbanite early retirees, and displaced employees from manufacturing downsizing. These changes need to be considered so that available skills can be maximized.
- Opportunities for advancement, as well as a mix of employment and skill requirements, attract new workers. Considerable emphasis needs to be placed on the need for upskilling and continuing education for rural workforce to adapt to changing needs of employers.

In Ontario, MTCU is addressing the generic labour market issues if temporary workers, entrepreneurship, small-business training, e-learning, upskilling and youth attachment.

There are other labour force issues which have a particular interest to rural labour force research including:

- Effective methods of addressing cultural barriers to re-skilling
- Implications for rural workers and their families of reduced/eliminated manufacturing employment
- Evaluation of current e-learning models to meet rural training needs.
- Facilitating upskilling of rural displaced workers to new opportunities
- Challenges and solutions for attracting professionals (medial, allied health, engineering etc) to rural areas
- Attraction and retention of working aged immigrants and their families into rural labour markets from urban centres
- Impact assessment of the rising transportation costs on workers in local/regional labour markets.

4: Critical Success Factors

4.1 Description

- Policy and program development requires access to critical data. The discussion recognized that access to basic foundational data sets was a key starting point but there was also a requirement for evidence-based policy research.
- The research evidence is useable by other ministries and provincial policies and programs reflect this input.
- Is there political support for a rural research agenda?
- Are there sufficient resources applied to rural policy research? There was considerable discussion here about the current limitations of the rural research budget.

- Will rural stakeholders and others utilize the research?
- Will there be evidence of stronger, more viable rural communities?
- The expected outcomes should be specific and measurable.
- OMAFRA funded research should be amenable to economic evaluation e.g. calculation of return on investment or information that improved information policy decisions.
- Ultimately, does the rural policy research raise the profile/understanding of rural Ontario?

5: Other Related Considerations and Recommendations

5.1 Other Recommendations

- Understanding the complexities of regional economies is an important first step in creating strong rural policies and this research requires significant resources.
- The importance of sector-based research e.g. rural tourism, rural manufacturing, forestry, agriculture etc. to place-based research.
- The areas of community and downtown revitalization e.g. the study of the role of small downtowns.

BIO-ECONOMY – INDUSTRIAL USES

1: Description and Scope of this Theme

1.1 Theme Description

- **'Bioeconomy**' refers to the exchange of products manufactured --- in whole or in part --- from renewable biomass resources. In this sense, the bioeconomy is an integral part of the larger economy. While renewable biomass resources could come from agricultural, forestry or marine sources, the focus of this theme is that portion of the bioeconomy which is or could be generated from agricultural biomass. "Bioeconomy" implies that food/feed and non-food/feed biomass could be the foundation for value-added activity in one or more markets, and could be part of competitive growth and prosperity strategies in a given region. Especially in the near term and perhaps for the foreseeable future, bioproducts are likely to be manufactured from blends of biomass and conventional materials. As a result, biomass and conventional feedstocks are now and will continue to be part of the same material chain. To varying degrees, biomass will be substituted into material chains in place of materials currently derived from fossil fuels, and will be used to manufacture products with real commercial value.
- **'Industrial Uses'** implies the transformation of biological materials into feedstocks for use in manufacturing or in energy systems. As a result, this theme requires consideration of the primary and secondary processing technologies by which biomass is transformed; these technologies may utilize biological, chemical, mechanical, thermal or other conversion processes. "Industrial uses" also implies the need to consider proximity of agriculturally-derived biomass to industrial users, the existence of appropriate transportation and storage infrastructure, and the relative ease or difficulty in substituting a particular bioproduct for a synthetic competitor (often made with fossil fuels) in industrial use.
- **The Bioeconomy-Industrial Uses theme** encompasses three major areas of focus, all of which involve use of agriculturally-derived biomass to produce some type of bioproduct. The three major product categories considered here are:
    - Biomaterials – includes bioplastics, biobased blends, natural fibre composites, biobased nanocomposites, biofoams, biorubber, biobased paints and coatings, bioadhesives, and bioinks, and natural fibres, as well as the resulting end products (e.g. textiles, carpets, mats), rigid components (e.g. tiles, panels, beams and posts, tubes/pipes, casings, or other formed products), or granulated products (e.g. chips, pellets, dust).
    - Biochemicals – industrial chemicals (e.g. cleaners, lubricants, sealants, solvents,), intermediate biochemicals (e.g. ethylene), chemical inputs/feedstocks for production of other products (e.g. oils, phenols, resins) or biotech products where at least part of the

product is a biological organism or component (e.g. enzymes, molecular probes, microbes, yeast, bacteria).

- Bioenergy – energy feedstocks (e.g. ethanol, methanol, butanol, biodiesel, bio-oil, biogas, pellets, hog fuel) as well as the end products (e.g. electricity, thermal energy).

- **Nutraceuticals and functional foods are excluded:** Biomaterials and biochemicals also have many applications in health care, where their use requires demonstrated compatibility with direct use in or on the human body. Exploration of this theme excludes nutraceuticals and functional foods which are considered under the Food for Health theme. However biopharmaceuticals and cosmetics are considered in the Bioeconomy-Industrial Uses research theme.
- **Feedstocks** are defined as: biomass intended for use in and subjected to some form of processing to prepare the biomass for use in manufacturing or energy generation processes. Residuals from conventional agricultural crops (including food crops) are often referred to as 'waste' and are considered a potential source of biomass for bioproducts. Other feedstocks could be bioenergy co-product streams such as low or negative value byproducts from lingo-cellulosic biofuel industries (also from paper and pulp industries), crude glycerol from emerging biodiesel industries, Distillers' Dried Grains with solubles (DDGS) from corn ethanol industries, soy meal and canola meal (from soy/canola oil industries), CO_2, food processing waste streams, and energy crops like hemp or miscanthus. Exploration of this theme specifically includes these feedstock sources as well as 'waste' from such non-agricultural sources as municipal solid waste streams. Blending these materials with agricultural feedstocks may be the most cost-competitive approach to manufacturing bioproducts.
- **Definitional Flexibility**: OMAFRA allows some definitional flexibility to encourage a more open innovation system (e.g. provide R&D flexibility to look at synergies between industrial and food/fuel uses --- as an example, the use of CO_2 from ethanol production as growth enhancer in greenhouses or potential feedstock for polycarbonate plastics. Also allow inclusion of biopharmaceutical, nutraceuticals, functional food and cosmetic R&D if it can enhance economics of an existing biorefinery (e.g. ethanol, biodiesel, biochemical facility)
- **The Concept of Sustainability:** There is significant potential (environmental) sustainability benefits in bioproducts --- linked to renewability of feedstocks, post-farm gate activity, conversion, product use and disposal, and the effects of these activities. Generation of strong comparative data is needed to address green standards of industrial bioproducts and build public confidence. However, while beneficial, these benefits should not be automatically assumed to be part of the definition of bioproducts.

1.2 Content Components of the Theme

Strategic Choices: The following are strategic choices as key components of moving forward in the Bioeconomy-Industrial Uses theme area:

- The concept of a hybrid economy --- based on the co-existence of products of bio and non-bio origins, as well as products which are themselves a blend of bio and non-bio feedstocks.
- A focus on higher value-added products, which are expected to be niche markets with significant customer value. The Panel concluded that Ontario's agricultural sector is more likely to be competitive in these markets than in commodity markets.

- The concept of total utilization of feedstocks and residuals --- a residual from one process may be an input or feedstock to another process. The ultimate objective must be total utilization of biomass, with no 'waste'. This imparts both business/commercial and environmental benefit.
- A value chain perspective --- adoption of a feedstock-to-product perspective against which research investments would be evaluated.
- Pursue Ontario's advantage and opportunities for entering into ethnic, niche and identity preserved markets
- Confirm that the best global competitive strategy is to build on excellence and corporate partners, preserve identity, and start with the end-use consumer

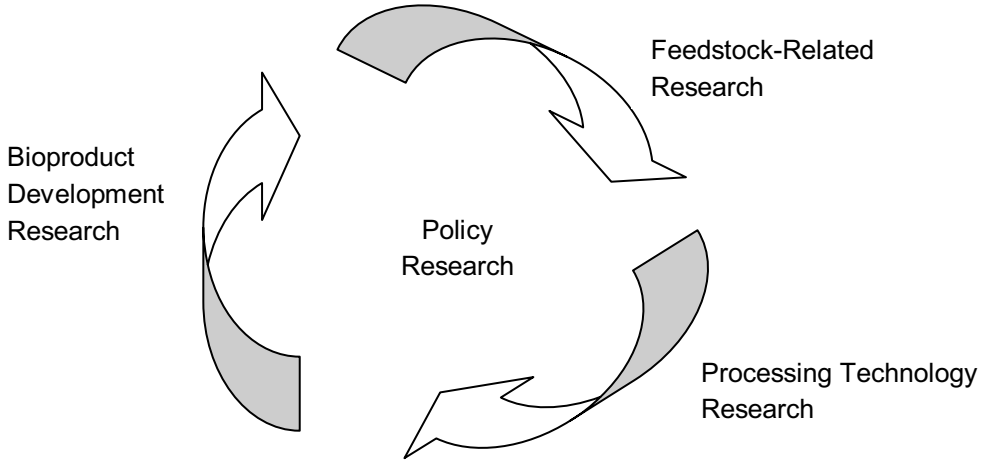
Key Infrastructure:

- Existing research capacity in both public institutions and private industry. Centres of Excellence, upon which industry as well as academe may draw, are also key components of infrastructure.
- Manufacturing infrastructure.
- Agricultural productive capacity, including expanded use of marginal lands (lands other than Classes one or two).
- Networking and relationship-development infrastructure, especially across sectors and disciplines.

1.3 "Mapping" The Bioeconomy-Industrial Uses Theme

Given of the complex, non-linear nature of the components of the "Bioeconomy-Industrial Uses" theme, mapping the "system" is also a very complex process. A very simple version of the system is presented below.

A more productive approach would be to map individual opportunities or products; this should be done at the early stage of each opportunity exploration with the objective of assessing prospects for successful outcomes and the system components required for that particular opportunity, as well as identifying assets which could be brought to bear on the opportunity and barriers which must be removed or circumvented (if possible).



2: Context and Background for this Theme

2.1 Context and Background

- OMAFRA requires integration of bio-economy theme priorities with priorities from the other 7 themes into a multi-theme research program with an approximately five year time horizon.
- Until now, research projects devoted to the Bioeconomy-Industrial Uses theme have not been a major part of OMAFRA's research programs. As a result, the context is well described for more intensive pursuit of these opportunities in future and underscores the need for OMAFRA to modify existing programs and processes to incorporate considerations and characteristics associated with this theme.

2.2 Key Assumptions

- Economic challenges to the Ontario economy will continue. Energy costs are expected to remain high for the foreseeable future. Market globalization will continue.
- Although some commodity markets may show ongoing strength (e.g. grains), Ontario will have increasing difficulty in competing in most low value-add markets. As a result, a shift to products with high-value added will be the most likely route to success for Ontario.
- Ontario has substantial agricultural resources which continue to be available for the production of a diverse set of products – including food, feed, and bioproducts.
- Climate remains a largely uncontrollable factor in the production cycle but it constrains rather than eliminates opportunity.
- Agricultural production in Ontario will continue to grow and related issues such as urban encroachment, environmental impacts of agricultural operations, and proximity of production and processing facilities to markets will require ongoing attention. Benefit to Ontario's agricultural sector should be one of – but not the only – criteria associated with research in this theme area.

2.3 Trends

- Ontario's economy is undergoing significant change – in the agricultural sector and well beyond it. The entire value chain (from feedstock to finished product) is becoming more tightly integrated, requiring closer collaboration between the agricultural sector, researchers and innovators working in multiple sectors, and receptor capacity. Requirements for integration and collaboration must be built into OMAFRA's research programs supporting this theme.
- The public policy environment for Ontario bioproducts will become more complex as other jurisdictions advocate and adopt standards for "green-ness", and the potential benefits – as well as outstanding issues – associated with bioproducts continue to attract attention.

2.4 Opportunities

OMAFRA can extract maximum value from the bioeconomy if it capitalizes on these opportunities:

- High value-add products, often associated with niche markets, rather than low value-add global commodity markets in which Ontario has increasing difficulty in competing.
- Local/domestic markets as well as international ones (e.g. energy products which can be used within the province to displace out-of-jurisdiction energy products).
- In the near-term, bioproducts which blend conventional and bio-based inputs, especially when those bio-based inputs come from residual or 'waste' streams associated with agriculture, southern woodlots, municipal solid waste or fibre-intensive manufacturing.
- Over the longer term, bioproducts in any of the theme subcategories (biomaterials, biochemicals, bioenergy) which can address a market need in a cost-competitive way based on a competitive advantage for Ontario, and offer benefits to the province's agricultural sector.
- Innovation potential of small and medium-sized enterprise (SMEs) as well as large industry and research institutions.
- Becoming a world leader in creating a public policy environment that is supportive of bioproduct development and introduction without disregarding the need for accountability in the use of public funds, protection of health and safety, and the need for environmental protection/improvement.

2.5 Issues and Barriers

- **Potential of the Bioeconomy Must Be Validated:** The emerging bioeconomy, which is simply a part of the larger economy, has potential to contribute to the Province's prosperity but this potential has not been validated. Research which helps to scope the arenas in which Ontario has the most opportunity would be advisable as guidance to annual research funding decisions.
- **Some Enabling Components Still Required**: Some – but not all – of the foundations are in place to pursue the potential of the bioeconomy. The most important components which need to be put in place are 1) organizational structures and processes which will accelerate Ontario's pursuit of opportunity and 2) linkage development both within and outside government to enable stakeholders to increase the Return on Investment (ROI) from research funding and capture economic opportunity.
- **New Concepts Must Be Introduced**: Successful pursuit of opportunity in the bioeconomy requires that new concepts make their way into research, development, commercialization and public policy associated with the bioeconomy. First and foremost is the concept of a value chain where all efforts are directed toward outcomes that will deliver economic benefit to the province and its agricultural sector. Other key concepts are interdisciplinarity in research, total utilization in processing and product development, and life cycle analysis as a tool for assessing environmental benefit.
- **Continued Leadership Needed**: OMAFRA should continue to provide leadership in articulating and stimulating agriculture's role in the bioeconomy but this must unfold in partnership with other Ministries, institutions and industry (both large and small).

2.6 Enabling Components of the Theme

Many of the research foundations of a bioproduct economy are already in place (e.g. research infrastructure and human capital). However to keep competitive on a global scale, Ontario will need to continue to invest in both basic and applied bioproducts research; by definition, research investments in this theme are more likely to be concentrated in applied areas than basic science.

The new(er) foundational components are:

- Linkages which deliver the value add aspect of bioproducts from agricultural biomass. (e.g. link with various food/feed/crop/chemical processors and capture the various streams (primary and residual) for use in products with high value-add; links between crop improvement, harvesting, bioproduct processing, modification of biomass, refining residues, as well as characterization and analysis of the bioproducts (bioenergy, biochemicals and biomaterials) from the molecular to macroscopic scale.
- Public policy and regulatory research which supports a successful bioeconomy holds the opportunity for Ontario to be a leader (as California is). One element of this could be an understanding of the impacts of the bioproducts sector on other sectors.
- Government incentives to promote technology transfer and to create market pull. Examples could be procurement policy (Province should buy what is made/ manufactured here.) or changes to crop insurance and advance payment programs for producers.

2.7 Interdependencies and Linkages with the Theme

Better integration of multiple stakeholders in important efforts to advance the bioeconomy, and building linkages to enable researchers to better understand and incorporate industrial/market considerations in their work. The specific types of linkages and dependencies identified were:

- Linkages to Industry/Manufacturing: Industrial and manufacturing linkages are key (to expedite bioproduct adoption and commercialization); this will require consideration of industry standards (quality assurance) and regulatory requirements. The energy/bioenergy sector was identified as a sector with which linkage development is especially important. Other sectors noted were forest product industry (pulp and paper industry), the chemical industry, and other manufacturing industries (auto parts, packaging, furniture and building products).
- Linkages to Other Ministries/Research Institutions: Moving from being an OMAFRA to OMAFRA-led initiative science and technology initiative for the province; this implies that linkages with other Ministries with science and technology interests and research institutions would be key.
- Linkages which are Geographic/Transportation-Focused: Linkages between processing/manufacturing/transport and agricultural (production) sectors due to sensitivity of economics to proximity/distance from field/forest to processing/manufacturing sites.
- Linkages to International Arenas: Take the theme in this research and industrial highly qualified personnel (HQP) to the global stage; engaging with decision-makers in industry in other jurisdictions is an important linkage for this theme.
- Interdisciplinary Linkages: with fields such as environmental research (e.g. on the consequences of deployment of new instead of traditional crops.

3: Research Areas and Priorities for this Theme

3.1 Description of Research Areas

Four priority research areas are identified: feedstock-related research, processing technologies research, bioproduct development research, and policy research.

A **Feedstock-Related Research** is defined as research to create, unique, sustainable, and/or more robust bio-based/organic feedstocks with the aim of long-term market viability. This includes research on organic waste streams and research into delivery and farm gate processing, storage, and transportation. This is the research area in which OMAFRA – UofG has the greatest potential to contribute in the provincial context.

Examples of research that might be considered under this research area include but are not limited to:

- Utilization of "waste" streams as value-added bioproducts
- Development of new or improved crops beyond traditional or existing commodity crops
- Feedstock development, quality development, storage and production optimization of ligno-cellulosic biomass on marginal land, with reduced water and fertilizer use
- Biotechnology for improved agronomics, improved quality of raw materials for industrial uses
- Enhanced feedstocks for use as combustible (or liquefiable) energy source (e.g. higher biomass yield per acre, increased drought and pest tolerance, increased transportation efficiency)

B **Processing Technologies Research** is defined as research into methods and processes for converting/refining feedstocks to enable cost-competitive products for a variety of industrial uses. This type of research should work towards an integrated approach. Processing technologies which use multiple/combined feedstocks should be favoured. The ultimate outcome of this type of research is increased value, either of a single component, or across products. This type of research includes development of processing technologies that are scalable to meet local needs as well as the needs of larger facilities.

OMAFRA particularly needs outcomes of research focused on the agri-technology side of this component.

Examples of research that might be considered under this research area include but are not limited to:

- Fermentation, thermal, chemical and/or mechanical processing of the optimized plant biomass to yield bioproducts
- "omics" research to enhance input/output traits for desired product streams encompassing total use (crops, microbial); this could span all areas of bioenergy, biofibre/biocomposites, or biochemicals
- Catalytic combustion/conversion of biomass

- Integration with existing chemical production (e.g. understanding of petroleum processes and opportunities)
- Nanotechnology-based approaches for purification and aptamers (binding molecules)
- Fractionation of processed food/feed/specialty crops to capture very high value co-products which remain after processing (biochemicals) and conversion technologies have been utilized
- Total utilization and integrated production of food /feed/ specialty crops and high value/added value co-products

C **Bioproduct Development Research** is defined as research undertaken with the objective of incorporating the science (if successful) into particular product applications. The product may be entirely bio-based, an ingredient substitution, or biomass used in combination with fossil fuels. The bioproduct must have potential value to agriculture in Ontario. This includes products made from southern Ontario woodlots but not boreal forests; forest products/residuals may be a component or part of a blend but a product which is 100 per cent from the boreal forest is not included in this definition of Bioproduct Development Research.

OMAFRA would benefit from research as a result of collaborations with other Ministries and universities in Ontario which are recognized leaders in research under this component.

Examples of research that might be considered under this research area include but are not limited to:

- Value added bioproducts (plastics, complex chemicals, high-end bio-materials, enzymes, enabling bio-technology such as microbial tools/products for bio-remediation and to drive bioprocesses)
- Next generation bio-fuels – bio-diesel, higher-chain alcohols (less hydroscopic and easier to separate from water than ethanol), enhanced biofuel feedstocks with less lignin content (allows easier enzymatic digestion into sugars); bioalcohol from ligno-cellulosics
- Safer biochemicals from corn, soybeans, other crops, and agricultural residue streams, as substitutes for petrochemicals
- High performance micro-fibres, nano-fibres and carbon fibres for light- weight, structural composite applications
- Bio-fillers, composite reinforcement fibres, and biochemicals from low cost agricultural residues and biofuel co-products streams

D **Policy Research** is defined as research on the short and long term implications of government policies including policies that are perceived to be disincentives to the competitiveness of the bioeconomy. The Bioeconomy-Industrial Uses theme includes micro-scale policy (e.g. regulatory definitions of types of biomass, consumer perceptions of bioproducts) but not macro-scale policy (e.g. value of Canadian dollar, international trade agreements).

Examples of research that might be considered under this research area include but are not limited to:

- Economic research on bioproducts to drive policy decisions. A particular high-priority area of policy research would be identification and removal of any barriers to the full utilization concept.

- Research into sustainability and life cycle impacts, which can be integrated into planning stages of research projects. This research would consider the short and long-term implications of bioproduct development with a view to competitiveness.
- Identification of incentives and disincentives for new/improved crops; design of policies and programs to remove/reduce disincentives and increase the impact of incentives (done well, this could be a competitive advantage for Ontario).

Note that proposals which include proof-of-concept research directed to agriculture should be explicitly included as eligible projects. Given that there are other research funds (e.g. NSERC) for basic research, the emphasis in research proposals is expected to be on applied or adaptive issues.

4: Critical Success Factors

4.1 Description of Critical Success Factors

Ability to Shape Organizational Structures and Responses, which include:

- Purposeful collaborations **---** the ability to partner across institutions (scientific disciplines, universities, government departments, and industry sectors) to achieve synergies and convergence of knowledge, expertise and technologies
- Flexibility in program design and delivery --- integrative programs that encourage interdisciplinary research (e.g. Bioproducts Research funding, The Sustainable Bioeconomy Centre at Queen's University)
- Research investments being driven by both applied (industry-driven) and strategic (government policy-driven) goals, and being targeted to larger multidisciplinary research projects
- The ability to create critical mass and investment in a priority research area to ensure success and global leadership
- Research funding processes: less cumbersome funding models and application processes, increased funding levels and time-spans. There is also an opportunity to build in clearly defined quantitative milestones in projects (especially important for multi-year projects)
- Timely decision-making on funding decisions to ensure that research can be undertaken in a timeframe in keeping with the global competitive environment
- Continuity among decision-makers: The bioeconomy is a very knowledge intensive field. OMAFRA needs to provide more continuity in bioproduct specialists and senior management. After someone gets up to speed, the ministry rotates them through other positions and the process of getting someone else up to speed starts all over again

Ability to Adapt Key Parts of the Value Chain:

- Changing transportation modes: (e.g. encourage movement from road transportation to rail and water, or multi-modal systems)

- Modified Use of Production and Processing Environments --- from redeployment of 'marginal' lands to new/improved crops, and use of greenhouses for feedstock optimization studies to smaller-scale technologies used close to source for primary processing (e.g. initial component separation, densification)
- Application of integrative concepts in processing technology and commercial settings: such as 1) the hybrid economy concept, 2) total utilization and biorefinery concepts 3) technology convergence 4) interdisciplinary research and development and 5) Cradle to Cradle and Reuse, Reduce and Recycle product development

Ability to Deliver Highly Qualified Personnel (HQP): To support and to meet the requirements of the rapidly growing bioeconomy-based industrialization globally, human capital with adequate knowledge and training must be created. Special emphasis should be given in developing new graduate level educational program in bioproducts and engineering themes. Coordinated federal-provincial action could deliver this. However, the Panel believes that primary responsibility for ensuring that the Province's HQP needs are met rests with the Ministry of Training, Colleges and University and the Ministry of Research and Innovation. OMAFRA should be a contributor to the program development processes of those ministries.

Ability to Develop and Implement Supportive Policy: while demonstrating accountability for public investment in agricultural research, encourage appropriate levels of R&D and innovation investment in bioproducts, adopt a life cycle perspective across all policy areas, introduce procurement policies which support domestically-produced bioproducts, encourage investment incentives into bioproducts, and introduce regulations which support production, manufacturing and commercialization of Ontario bioproducts. Another important element of the policy environment is balancing IP protection while adding to the pool of public knowledge and supporting public education and outreach. The Panel believes that Ontario has an opportunity to be a leader (like California) on the policy and regulatory aspects of a successful bioeconomy.

Ability to Target Collaborators and Customers: by continuing to work with/engage innovative large firms while increasing emphasis on stimulating growth of small and medium-sized enterprise (SMEs) which can serve as pilot sites for new feedstocks, processes and products, are often more nimble in their competitive response than larger enterprise, and may be more directly linked to local/domestic markets.

5: Other Related Considerations and Recommendations

5.1 Considerations

- Create momentum behind initiatives OMAFRA is funding. Build networks and work collaboratively.
- Review the research priorities from other themes and identify cross-cutting research priorities (e.g. a research priority which addresses a need in the food or feed sector but could also inform industrial uses of agricultural biomass). Themes such as production systems, value chain and

rural policy are likely to have areas of overlapping interest. Note that of the eight themes mentioned in the Challenge Paper, the first five are complementary.

- Create forums for issues beyond research funding (e.g. food versus fuel, food versus bioproducts); the private sector has the same concerns. Researchers need to be engaged in these discussions too.

EMERGENCY MANAGEMENT

1: Description and Scope of this Theme

1.1 Theme Description

Based on a recommendation of the Emergency Preparedness expert panel and the consent of ARIO, the name of this research theme has been changed from Emergency Preparedness to Emergency Management, which was felt to be more reflective of the scope of the theme.

Primary Objective of the Emergency Management Research Theme

The ultimate goal of this theme is to direct and maximize research activities and financial and human resources to support a proactive, coordinated and comprehensive approach to managing agri-food emergencies in Ontario to lessen their likelihood, frequency or impact.

Definition and Scope of the Theme

The Emergency Management research theme has an emphasis on "One Health" and encompasses issues relating to zoonoses and public health, foreign animal disease, plant pests, food safety, plant and animal disease epidemiology and surveillance, risk management, and related emerging issues.

Research conducted under this theme will support the five 'core components' of emergency management[2] as they relate to agri-food emergencies.

Pre-Event:
- Prevention – actions taken to prevent an emergency
- Management – actions taken prior to an emergency to ensure an effective response

Event:
- Mitigation – actions taken to reduce the effects of an emergency or disaster
- Response – actions taken to respond to an emergency

Post Event:
- Recovery and restoration – actions taken to recover from an emergency

The focus of the theme will be on disease agents and pests whose sudden emergence or re-emergence in Ontario requires an immediate and comprehensive response for containment, or on endemic agents that are known to give rise to exigent circumstances (e.g. foodborne pathogens). In general, emergencies are events that cannot be handled with typical resources, and require an urgent, significant and coordinated response. Emergencies may arise by inadvertent or intentional

[2] Emergency Management Doctrine for Ontario

means (e.g. bioterrorism or the deliberate introduction of a hazardous substance into the food supply).

1.2 Content Components of the Theme

There are four core subject matter components within this theme.

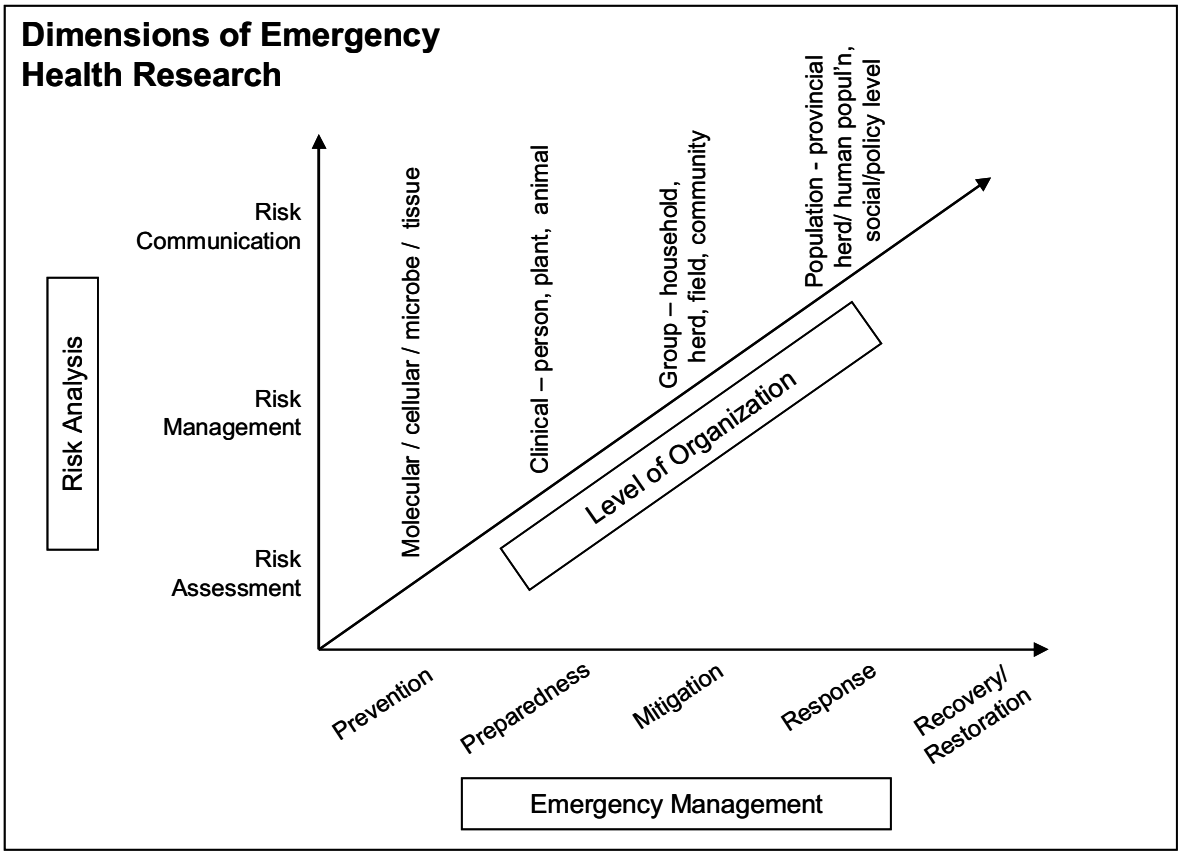
Animal Health and Welfare: Includes surveillance and emergency management issues relating to infectious diseases of animals and direct and foodborne zoonoses. Animal welfare as it relates to emergencies is in scope. Animal welfare as it relates to production (e.g. housing practices, pain control), as well as research relating to production limiting diseases (e.g. pneumonia and mastitis) are out of scope and will be addressed in the Production Systems research theme. Diseases of wildlife and companion animals are in scope as they relate to zoonoses of significance to livestock and human health. Purely basic research (e.g. disease mechanisms/bacteria pathogenesis), while important and necessary research, is beyond the scope of what OMAFRA should resource under this theme.

Plant Health: The focus will be on emergency management issues relating to plant pests. Plant pests include insects, other invertebrates, bacteria, viruses, nematodes, fungi, weeds and other invasive species that affect the health of agricultural commodities. Mycotoxins produced by certain fungi are an important exception, and some invasive plants are noxious and can present a public health hazard. Mycotoxins produced by certain fungi are an important exception. Research relating to innovation in pest management will be addressed under the Production Systems research theme.

Food Safety: Food safety research needs and issues, including analytical methods, risk assessment and risk management are within the scope of this theme. Food safety research related to this theme will be primarily addressed and resourced under the existing competitive Food Safety Research Program.

Related Public Health: The research theme relates to public health as it pertains to human-animal interaction, zoonoses and food safety research.

The following illustration depicts three dimensions of emergency health research which include risk analysis, emergency management and level of organization. This illustration will be useful into the future in the evaluation of proposed research projects, and to help describe and map the progress made in Emergency Management research over time along these three continua.



2: Context and Background for this Theme

2.1 Context and Background

Outbreaks such as SARS, BSE, avian influenza and invasive plant pests illustrate the concept of a 'global disease ecology'. Outbreaks that have occurred in Ontario/Canada illustrate the profound human health, animal health, plant health, economic, and environmental impact of these events. The economic impact of outbreaks can spread faster and cast a wider net than the actual morbidity and mortality they cause, with secondary disruption of supply chains and other effects. For example, the SARS outbreak had devastating effects on travel and tourism in Canada and the country saw a dramatic drop in GDP during the outbreak. The cost of BSE in Canada has been estimated to be around $10 billion in lost trade and compensation[3]. It has been estimated that the damage resulting from past introductions of harmful invasive plant pests on agricultural crops and forestry in Canada is $7.5 billion annually[4]. The cost of follow-up measures to control and/or eradicate disease can exceed the initial costs of outbreaks. It has also been noted that "fear of infection can result in the greatest economic damage" (ING Bank).

[3] May 22, 2008. U of O Research Examines Risks of BSE. http://www.thecattlesite.com/bse-news/22946/u-of-o-research-examines-risks-of-bse

[4] An Invasive Species Strategy for Canada. 2004. Environment Canada. http://www.ec.gc.ca/eee-ias/Default.asp?lang=En&n=98DB3ACF-1

Furthermore, while Canadians enjoy one of the safest food supplies in the world, Health Canada estimates that there are as many as 13 million cases of foodborne illness each year in Canada, with health care costs alone estimated to be up to $3.8 billion dollars annually[5].

In addition to the adverse health and financial costs of outbreaks and illness, response and management options can have deleterious environmental impacts (e.g. mass culling and disposal of animals, massive tree removals, and chemical spraying to control plant pests or mosquitoes for West Nile Virus). The impact of invasive alien species on native ecosystems, habitats and species is severe and often irreversible. Invasive alien species can also result in significant social costs, especially to rural Canadian and Aboriginal communities that remain dependent upon agricultural and natural resources[6].

The province is challenged with the task of developing risk management systems to prevent and respond to agri-food emergencies, and has the responsibility to help ensure a safe food supply and a healthy population. To do so requires an adequate science base to support government and industry decision-making.

The expert panel has embraced a 'One Health' approach as the way forward to meet the challenges identified within this theme. The 'One Health' philosophy recognizes the '"essential link between human, domestic animal and wildlife health and the threat disease poses to people, their food supplies and economies, and the biodiversity essential to maintaining the healthy environments and functioning ecosystems we all require" [7]. One Health emphasizes the critical importance of interaction among scientific disciplines, jurisdictions, and health communities (i.e. between different animal sectors – livestock, wildlife, and companion animal – and between the human, animal and plant health communities) and is gaining momentum as the guiding principle in the development of animal, plant, human and environmental health initiatives in many jurisdictions, with the goal of improving the well-being of all species. The full scope of One Health is broader than the scope of this particular research theme, but its main principle of a unified, forward-looking and holistic approach to health and disease is applicable to the Emergency Management research theme.

2.2 Key Assumptions

The incidence of emerging infectious disease events, and their impact on Ontario, has risen significantly over time. The exchange of pathogens among livestock, wildlife, and humans is increasing and a localized disease event can quickly spread globally, sometimes within the incubation period of a disease, making detection and proactive control difficult. The possibility of intentional introduction of an infectious agent is also a growing concern.

Conditions that favour the persistence of existing threats and the emergence of new or variant diseases of plants and animals, zoonotic and vector-borne agents, plant pests and invasive species will continue. These include:

- Changes in agricultural practices, including industrialization and intensification

[5] Government of Canada News Release, June 3, 2008. http://www.healthycanadians.ca/media/2008-06-03_e.html
[6] An Invasive Species Strategy for Canada. 2004
[7] http://www.oneworldonehealth.org/

- Increases in population density (both human and animal). Increased demand for meat in developing nations will intensify livestock populations
- Complex global movement of people, animals, and agricultural products and global sourcing of food and feed ingredients which can increase the risk of introduction and spread of hazards where they are not normally found.
- Climate change (e.g. affecting the ecology of pests and disease agents, and increasing the probability of severe weather emergencies and related impacts on animal, plant and human health)
- Adaptation of disease agents and pests (increased resistance to control measures, antibiotic resistance, recombination events leading to an expanded host range or changes in virulence)

Failure to predict, prevent and/or manage these threats can have significant consequences including:

- Morbidity and mortality in human and animal populations
- Severe economic losses to agri-food producers and processors. Losses may include market share or accessibility to markets, recall costs, litigation, and lost product
- Environmental concerns (mass carcass disposal, chemical sprays, clear-cutting, loss of biodiversity, contaminated water supplies etc.)
- Non-tariff trade barriers (e.g. BSE, Plum Pox Virus)
- Loss of public trust and confidence in government, industrial/commercial agriculture and the food processing industry
- Other economic costs including business risk management claims, health care costs, lost wages and lost productivity, and losses to other sectors (e.g. tourism)

All reasonable measures must be taken to prevent the importation of foreign pests and diseases into Canada. Canada must likewise ensure that unwanted pests and diseases are not exported from Canada to other nations. This is essential to protecting export markets and trading relationships[8].

There is a need to distinguish between the process, management, and regulatory aspects of emergency management (of which there are many), and the aspects that are related to research. OMAFRA undertakes many activities to contribute to Emergency Management, of which research is only one. Policy and program development, coordination and delivery are major roles of government to encourage integrated systems that effectively manage animal, plant and public health risks. Behavioural and management changes will continue to be promoted by a combination of tools including advice; best practices; education and training; financial incentives; and licensing, inspection, compliance and enforcement activities. Research has an important contribution to make and can be considered an enabling foundation to defining problems, exploring solutions, and designing and verifying effective and appropriate tools[9].

---

[8] An Invasive Species Strategy for Canada. 2004. Environment Canada. http://www.ec.gc.ca/eee-ias/Default.asp?lang=En&n=98DB3ACF-1

[9] Adapted from the Environmental Sustainability Research Theme - Priorities Discussion Document prepared by P. Joosse. 2007.

2.3 Trends

In addition to the key trends and assumptions listed above, there are additional trends and issues that have been identified that may influence emergency management into the future.

Biological

- Emergence of variant forms of formerly benign organisms (e.g. Circovirus and *E. coli* O157:H7)
- Antibiotic and multi-drug resistance in human and animal disease agents is increasing
- Increasing importance of wildlife and vector-borne diseases as a contributor to emerging human infectious disease events globally
- Increasing numbers of individuals in sub-populations susceptible to foodborne illness and other infectious diseases (e.g. immuno-compromised)

Socio-Cultural

- There is a general trend toward increased public accountability in agriculture and food production. It is probable that societal pressure for rigorous animal welfare, food safety and quality standards, and environmental stewardship will be increasingly influential in the marketplace and in policy development
- Consumer pressure is a key driver in influencing some aspects of animal welfare and agriculture (e.g. production and rearing practices, transportation and euthanasia practices). These issues can become critical in emergency situations such as border closures or foreign animal disease depopulation
- Evolving consumer demands, demographics and behaviour can impact the frequency or impact of adverse events, particularly as they relate to food safety (e.g. minimally processed foods, local foods, farmers markets, larger immigrant populations, exotic foods, convenience foods, eating out, religious and cultural food practices)
- Food security is becoming an increasingly important issue
- Impact of activist and advocacy groups
- Media influence in outbreaks and other adverse events

2.4 Opportunities

Several Ontario-specific opportunities and niches have been identified that can support the advancement of research in this theme.

- Although gaps exist, Ontario has an exceptional critical mass of expertise in the subject areas related to emergency management research, representing good opportunities for multi-disciplinary and collaborative research.
- OMAFRA is currently developing options to further strengthen animal emergency management systems. Research conducted under this theme can help support, inform or fulfill those strategies and aid in the development and prioritization of disease risk assessments.
- New one-time funding under the University of Guelph/OMAFRA agreement for the Animal Health Laboratory over the next five years should considerably increase the analytical and surveillance capacity in the province for animal and emerging zoonotic diseases.

- The recent establishment of the Ontario Health Protection and Promotion Agency represents an excellent opportunity to establish new linkages and create a hub of expertise that could become an international leader in the area of animal health, agriculture, food safety and public health.
- Likewise, the mandate of the recently established Centre for Public Health and Zoonoses at the University of Guelph aligns directly with this research theme and represents a network of U of G and other collaborating researchers with a focus on preventing and controlling emerging animal-related diseases that threaten public health.
- Ontario maintains a regulatory system for abattoirs, auction houses, the deadstock industry, and livestock medicine outlets. Data from these sources may have potential value in integrating with other sources of information to support surveillance activities.
- This priority setting process is an opportunity to inform the future direction of the OMAFRA Food Safety Research Program, and integrate and coordinate its objectives and outcomes with those of the Emergency Management research theme.

2.5 Issues and Barriers

There are several issues and barriers common to all the theme subject areas that impact our ability to develop or implement emergency management measures and/or can impact research in this area:

- Information access and management:
  - Information infrastructures are poorly integrated, highly dispersed and decentralized networks. There are a lack of mechanisms for planning and coordinating information collection (from farm-fork-hospital bed) as well as institutional obstacles to information sharing
  - There are constraints on data capture and sharing making it inaccessible; freedom of information issues; privacy legislation; intellectual property
- Lack of capability/failure to effectively utilize current knowledge and information
- Traceability systems are insufficient
- Systems do not exist to measure the effectiveness of interventions
- Disincentives to reporting (e.g. because compensation is not preapproved)
- Legislative and regulatory challenges (e.g. limited authority to act)
- Human and infrastructure capacity issues including:
  - Lack of trained human resources (e.g. pathologists, erosion of expertise in pest diagnostics and pest management)
  - Limited laboratory capacity and facilities (e.g. few facilities with adequate containment for plant pests)

Furthermore, it is difficult to 'prove' an adverse event has been avoided. The absence of events (i.e. good emergency management) may lead over time to an increase in public apathy and a reduction in resources available for emergency management. Therefore avoidance must somehow be made visible as a tangible value.

2.6 Enabling Components of the Theme

Four components are identified as being particularly important to advancing this theme both in terms of research and operational programs. They are included here, as they can be considered foundational to conducting research in this theme and developing and implementing effective emergency management strategies in Ontario.

Inventory of Current Research / Knowledge / Capacity.

- The need for an inventory of existing research and capacity is an important first step as OMAFRA embarks on research in this area. Considerable research relevant to this theme already exists.

- The cataloguing and use of historical and current research data, and leveraging knowledge from other jurisdictions (e.g. surveillance, best practices, biosecurity, lessons learned etc.) are important to the planning of future germane research projects. In addition, there is a need to understand Ontario's 'current status' in terms of management, mitigation abilities, response readiness, and recovery capabilities (e.g. current state of traceability and real-time premise ID).

Identifying and Establishing Key Linkages and Partnerships.

- To embrace a One Health approach to addressing agri-food emergencies, this theme requires multidisciplinary, multi-sectoral and multi-jurisdictional approaches to research. Collaboration and communication among research institutions, governments and industry stakeholders, as well as the international community is seen as being essential to meet the existing and future challenges of this theme area.

- OMAFRA needs to determine where the key linkages and dependencies are between human, animal and plant health and take an active role in collaboration and network development. Policy makers at the various levels of government, as well as the key commodity/processor groups, should be involved in research right from the start. Engagement of, and buy-in from, farmers, growers, processors, consumers, and industry organizations is critical, as these groups are the end users of research and often the front lines of our defence.

Strategies for Research Translation and Transfer.

- The timely communication and utilization of existing knowledge and new research generated under this theme is essential. There is a need for the development of processes that allow incorporation of science into policy development, operational practices, and decision-making.

Social, Legal and Ethical Aspects of Emergency Management.

- Some of the areas described below may be beyond the traditional focus of OMAFRA research, but learning and progress in these areas can support Emergency Management.

  Risk Perception and Communication: Risk communication is multi-directional and involves the public, producers/processors and the sector. Public perception of risk is often disconnected from reality and too often the government lags behind the media and other interest groups in getting their message across. There may be ways that public fear can be better managed and

informed prior to and during an emergency. Research on risk perception and how people respond psychologically/ emotionally in an emergency may lead to the development of new models of effective relative risk communication.

Industry Engagement: There is a need to understand what stakeholders are interested in, and how to achieve and maintain industry engagement, buy-in and compliance in the absence of an event. Producers and processors will need to see the benefits and the value for money of proposed interventions. Knowledge of emergency management and training of personnel working in the throughout food production chain is also important. Emergency response simulations can keep these issues on the radar of industry.

Legal/Ethical Issues: Lack of an Animal Health Act for Ontario was identified as a problem. A strategy or Act that defines chain of command (who does what, when, and on what authority) is necessary. A poor understanding of roles and authority in an emergency can slow responses and compromise effectiveness. Industry should clearly be defined as a partner, not just a participant. In addition, information and/or research on issues surrounding data sharing and access may help overcome some of the challenges identified in this report.

2.7 Dependencies and Linkages with the Theme

The importance of collaboration and partnerships is described in section 2.4 above. There are varying degrees of linkages or relationships of Emergency Management to the other research themes. Research conducted under some of the other themes may produce results relevant to risk assessment and emergency management strategies. Some specific connections identified among the themes are listed below, although not all of them directly relate to research in this theme:

- Production Systems – biosecurity, intensification of agriculture; good management practices related to emergency prevention and mitigation; best practices and innovation in pest management; plant and animal production and management practices can have direct impacts on animal health and welfare, food safety and by extension, public health
- Agricultural Policy – government regulation; farm management challenges; agricultural trade
- Product Development and Enhancement Through Value Chain – traceability technologies and quality/safety assured supply chains; improvement of business efficiency; also a tool to add and capture value by providing verification of credence attributes that may be difficult or costly to measure
- Rural Policy – rural/urban interface; rural infrastructure; community capacity
- Bioeconomy-Industrial Uses – The utilization of agricultural waste or by-products of industrial processes may have food safety implications (e.g. the use of dried distillers grain in animal feed may increase the carriage and shedding of *E. coli* O157:H7 in cattle). The food safety implications of novel, biodegradable packaging materials from cellulosic and other materials need to be considered.
- Food for Health – The development of novel foods and new food products that meet consumer demand for convenience; reduced salt, fat or sugar; no preservatives; as well as new and alternative processing methods may have food safety implications. Changes in primary production practices for the purposes of the development of foods with novel or

enhanced traits could have food safety or animal welfare implications (e.g. alternative animal diets).

- Environmental Sustainability – Plant pests, invasive alien species and emergency management activities can negatively impact ecosystems.

3: Research Areas and Priorities for this Theme

3.1 The Approach

Even though we cannot predict the exact nature of future emergencies nor their exact timing, we can be certain that some sort of emergencies will occur that will share some common and predictable emergency management needs. Research that supports horizontal or cross-cutting initiatives will result in the best return on our research investment no matter what happens specifically.

Spread of disease and pests is inherently exponential in nature, therefore little mistakes can turn into big emergencies and small, early precautions or interventions can avert large-scale emergencies. Research efforts should be primarily focused on prevention and preparedness in order to help transition emergency management from *ad hoc*, issue-specific initiatives to a proactive, preventative approach; integrated as required among disciplines, sectors and jurisdictions.

It is important to differentiate between areas which are regulatory or related to incident command / process versus those which require research input. There are many needs and issues important to advancing Emergency Management in the province, but not all require research to go forward. For example, traceability is a key aspect of Emergency Management; however, effective systems already exist and are being effectively applied in other jurisdictions, thus it is not a priority area for research.

3.2 Description of Research Areas

The goal of this research theme is to support agri-food components of emergency management in Ontario in order to lessen the likelihood, frequency or impact of agri-food emergencies. OMAFRA also has a responsibility to help ensure a high level of public health and food safety by reducing the risk of foodborne/ waterborne disease and direct zoonoses. This section describes the strategic research areas the expert panel felt that OMAFRA should champion. They are presented in a logical, unranked order.

A Threat Identification and Prioritization

There is a need to identify and prioritize threats to plants, animals, food safety and human health within the Ontario context to optimize the application of limited resources so as to strategically manage risk to acceptable levels of likelihood, frequency and impact. Risk assessments ask three questions: 1) What can go wrong? 2) How likely is the event to occur? 3) If the event happens, what is the magnitude of harm? The identification and characterization of potential hazards requires an evaluation and understanding of global trends in zoonotic and animal diseases and invasive alien species. Given that risk is a function of both probability and

impact, uncertainties in our understanding of the factors that influence these two components for a given hazard compromises our ability to rank risks and prioritize surveillance, detection and risk management activities. Assessments of potential adverse events should take into account health, economic, trade, ecological, social and political impacts, public perception, feasibility of control, as well as the variability and uncertainties inherent in the data.

B Detection and Surveillance

Surveillance is important to support the safe trade of plants, livestock, and animal and food products. Food and animal health surveillance is also important to public health. Being able to detect hazards and conduct surveillance to understand their normal frequency and distribution, and detect important changes early, helps to facilitate timely response so as to mitigate impacts. The data required to help evaluate the effectiveness of food safety interventions and other initiatives is currently limited. Integrated systems and information access and sharing among the health communities involved in Emergency Management is critically important, as is the development of databases. In addition, appropriate diagnostic tools are required to support surveillance activities. This may require the development of analytical methods for emerging hazards or the improvement of existing methodology (e.g. improved sensitivity, specificity).

Examples of research needs in this area include:

- Development and validation of detection and monitoring methods for animal diseases, plant pests and foodborne disease agents including:
  - Rapid diagnostics of exotic/emerging/novel pathogens and pests
  - Real-time and field-based/pen-side diagnostic tools
  - High-throughput methods
  - Development of appropriate and representative sampling strategies
- Systematic, laboratory, farm level, and follow-up investigation surveillance
- Identifying needs and gaps in linking human / livestock / wildlife surveillance systems for early identification including appropriate, unified reporting systems.
- Baseline studies to help understand changes in existing conditions for identification of future research projects.
- Examining cost effective and timely models for improved surveillance and data collection and cross-sectoral analysis (e.g. extensive and collaborative interfacing of animal and human health data). This could include high quality trend analysis, epidemiological investigations, and examination of the potential utilization of GIS platforms and, where feasible, geocoding of data to better understand and depict trends in the interface between animal and human health. Many new mathematical, statistical and geospatial techniques can be developed and applied.

C Pathway Analysis

Increasing diversity and volume of trade and travel result in the complex movement of people, food, animals, and plants across and within borders. Once introduced, pests and disease agents can spread provincially or nationally. Pathway analysis is a systematic assessment of the pathways along which a disease agent or pest might enter or move within and between Ontario farms and establish an outbreak of disease in plants, animals or humans. Understanding pathways of invasion and spread is important in order to identify the vulnerabilities and the weakest links from an Ontario perspective, resulting in the identification

of critical control points throughout the agri-food system so we know where to best target interventions. Research is needed to understand normal flow through the animal, plant and food systems as well as the factors that contribute to the emergence, transmission and persistence of infectious animal diseases, zoonotic agents and pests. This information will guide how to prevent, mitigate, detect, assess and respond to emergencies in the most effective and efficient manner.

Examples of research needs in this area include:

- Understanding and modelling the frequency, distribution, normal variability in space and time of animal and plant hosts at risk, as well as the frequency, distribution, and variability of hazards (eg virulent bacteria, viruses, etc) that can cause harm to the health of animals, plants or related public health on an emergency scale.
- Understanding and modelling of frequency of input, commodity and out flow including contacts, probability of transmission and factors influencing population susceptibility as these are the core factors that influence the number of new cases created by existing cases, the resultant scale of the outbreak, and the scale of the emergency.

D Prevention and Control of Disease

Preventing the introduction of a pest or disease agent is the most effective means to avoid or minimize risk, and can be considered the most cost-effective approach to emergency management. Effective prevention and control strategies are required that are affordable, predictable and can be broadly implemented. Research is required to support the development of best management practices. The designs of emergency management systems that pay for themselves through improved business efficiency during non-emergencies, but can be scaled up for use in emergencies have the best chance of adoption and success.

Examples of research needs in this area include:

- *Biosecurity measures*: Practical biosecurity programs are needed for each sector based on sound research as to the effectiveness of particular measures to reduce the introduction or spread of diseases or pests. New ways of limiting the impacts of adverse events (e.g. zoning/ compartmentalization) need to be explored, but the science to support such decisions may be lacking. Research is required to determine what degree of biosecurity is required in a particular context and when, as there is a point of diminishing returns.
- *Models of different approaches to prevention and control* may be built upon earlier models of system flow and pathways and disease modelling.
- *Food safety risk management*: including food safety measures on-farm and during processing, and new processing technologies. Many infectious agents that cause illness in humans do not have an impact on animal welfare or crop and horticulture production. This presents challenges in creating incentives for producers to implement control measures. Likewise incentives may be weak for food processors to implement food safety management programs.
- *Systematic review:* In some cases a large body of research knowledge already exists that would support policy and program decisions. Systematic reviews and meta-

analysis of global research can provide support for evidence-based decision making regarding prevention and control strategies.

- *Management of plant and animal populations in an emergency*: This may include effective euthanasia methods that are publicly acceptable, especially in large animals, and the identification of efficient carcass disposal strategies in Ontario. There is also a need for advances in effective disease risk management without mass destruction of healthy animals and plants (e.g. though the use of computer models).
- *Disease control strategies* such as vaccination.
- *Evaluation of the effectiveness of interventions*

E Benefit/Cost Analysis

Failure to plan ahead for emergency situations with the lack of clear plans for emergency response, puts considerable resources at risk. Information regarding the economic impact of possible adverse events is needed for both industry and the general public in order to assess the value of avoided losses (benefits) against the costs of investing in emergency management.

Emergency management initiatives and policies need to achieve their intended benefits and be cost effective for the agri-food industry and allow the sector to maintaining its competitiveness globally. Research is needed to evaluate the costs and benefits of potential risk-reducing interventions in order to prioritize risk management options. Modelling and/or analysis should ideally integrate the effectiveness of interventions in reducing risk, the resulting benefits from improvements in plant, animal or public health, and the time/effort and financial investment required for the intervention.

4: Critical Success Factors

4.1 The Approach

Complete success in this theme would entail complete knowledge, achieving near complete prevention and avoidance of all emergencies, as well as immediate containment and fully effective response to any unpreventable emergencies. Such success of “avoidance-of-loss” would be difficult to measure.

4.2 Description of Critical Success Factors

There are several factors over which we have reasonable control which can affect the success of research and other advances in this theme. The importance of collaboration and partnerships, research translation and transfer, and mining existing knowledge are substantial and these factors were described earlier in this document in section 3.3 (Enabling Components). Other factors identified include:

- Prioritization and allocation of provincial research funding and human resources. Resources need to be adequate

- Laboratory capacity to support Emergency Management
- Coordinated information management and information sharing strategies among the health communities involved to provide early warning of problems
- Education and awareness programs (public, producers and processors, veterinarians)
- Policies to support Emergency Management

Specific programs identified that are foundational to effective emergency management, and over which we have reasonable control, include:

- Traceability and premise ID
- Effective, documented, and audited biosecurity programs in place based on research
- Effective, documented, and audited surveillance systems in place with known test and system sensitivity and specificity
- Effective, documented, ever improving, scientifically sound emergency response systems in place, that are practised and used routinely

5: Other Related Considerations and Recommendations

5.1 Considerations

There are particularly important linkages between the Emergency Management research theme and the Production Systems theme that will have to be taken into account going forward.

Research is required to encourage the adoption of emergency management interventions and maintain industry engagement, particularly in the absence of an adverse event.

Certain policies can create conditions that can impact emergency management measures. For example, municipal bylaws that allow residents to keep livestock can result in animal populations that may be overlooked in an emergency, and can complicate disease surveillance and emergency response/eradication. There needs to be linkages between these policies and the sectors which they affect.

ENVIRONMENTAL SUSTAINABILITY

1: Description and Scope of this Theme

1.1 Theme Description

Sustainability refers to the achievement of an economic, environmental and social state which can be maintained indefinitely. “Environmental Sustainability” at OMAFRA focuses on maintaining the ability of natural resources (soil, air, water and biodiversity) to support and strengthen agriculture, food and bioproduct sectors and rural communities. OMAFRA is called upon to consider economic, public health and environmental aspects in order to achieve sustainable agriculture and food production. There is also a desire for rural Ontario to contribute innovative solutions to environmental issues.

Provinces have jurisdiction over the control and management of land use and emissions to the environment; much of the decision-making related to land use and production is therefore exercised by the provinces. The province is responsible for legislation and regulation regarding land use, agricultural and food operations, practices and impacts. The province also provides recommendations, guidance and programs for adoption of agri-environmental management practices. The legislative, regulatory and programmatic responsibilities of OMAFRA require specific avenues of investigation to support evidence-based policy and programs that may not be supported through other science and research programs.

Economic and population growth present opportunities and challenges for agriculture and the environment. Society plans and modifies the environment with a strong focus on the needs and desires of people. For this reason, the definition of environmental sustainability and the research requirements surrounding it has a strong focus on the basic needs of people. Furthermore, while farmers are good land stewards and environmental managers, their primary concern will be for sustainable agriculture and their own livelihood.

Environmental sustainability is also a critical component of agricultural production and it needs to be considered and incorporated into the other research themes.

2: Context and Background for this Theme

2.1 Context and Background

Sustainability of the agri-food system includes economic and social aspects as well as environmental aspects. However, in relation to the other OMAFRA strategic themes, this theme is

focused on the natural resources (soil, water, air, and biodiversity) which support and strengthen agriculture, food and bioproduct sectors, and rural communities.

In order to support innovation and advancement in the agri-food sector and address the concerns of society, OMAFRA invests in this research theme to:

1. Understand the agriculture and food sectors potential risks and benefits to soil, water, air and biodiversity resources;
2. Provide a scientific basis for the development of credible and defensible government policies, programs and initiatives;
3. Assess the impact of environmental policies on the agri-environment, and economic stability and opportunities for the sectors and rural communities; and
4. Identify opportunities for agriculture, food, and bioproducts sectors, and rural communities to provide solutions for societal environmental challenges.

2.2 Issues, Trends and Opportunities

The following are key insights to be considered in researching the environmental sustainability research theme, and more broadly, applying the results of research for the benefit of the government and stakeholders in the province.

- The basis for environmental sustainability is a solid understanding of biophysical processes and resiliency of the agro-ecosystem. Impacts of human activity, climate change or farm practices on the agro-ecosystem are often only observed on a **decadal or century long timescale.** As the lifecycle of the agro-ecosystem is on the order of decades, some research needs to encompass a significant portion of this cycle. For example benefits from the adoption of a new management system may be evident in a short time frame (1-3 yrs) whereas the negative consequences of this new management system may only appear over a longer time horizon (>10 yrs). Hence, a combination of both short-term and long-term research studies is required. Balance needs to be achieved between the need for long-term, sustained research and research to address more immediate drivers.

- It is important for environmental sustainability research to have projects/platforms from which holistic and **integrated data sets** for air, soil, water, biodiversity, land management and economics are collected and linked. Data needs to be collected with regard to general resource inventories (already existing but generally lacking in detail and quantitative information) in such a way as to document and measure evolution, trends and inconsistencies in the various resource bases. It is important that the data be organized in formats which can be integrated with past and future work and that the databases be maintained and made available to multiple agencies and researchers. These datasets can potentially be used to address multiple issues and to calibrate and validate models.

- Land management decisions which affect environmental sustainability are frequently made at the farm level. If research is to impact or influence environmental sustainability it needs to be **relevant to the farm level** of decision making and include the economic implications for the operation (i.e. profitability and liability).

- Land use planning and common resource decisions are made publicly. It is important to **communicate** accurately and succinctly to the public that information which relates to tradeoffs and risks about agricultural land use compared to other land uses. It is often easier to measure, document and communicate the negative impacts of agricultural production on the environment than the positive contributions. However, positive contributions such as carbon sequestration, open space, wildlife habitat, P-retention, source water protection, organic material utilization, and enhanced water management associated with efficient agricultural production should be recognized as part of an economic solution to societal environmental issues.

- The environment is only one of three aspects of sustainability, the others being economic and social. Farming-systems research that looks at all aspects of sustainability simultaneously and **integrated systems analysis** which allows individual experimental pieces to be "put together" in a holistic way, are approaches to research which should be pursued. These types of research are important to understanding the interaction between behavioural, economic and environmental drivers. Integrated systems analysis research is not easy to conduct, but it can be done routinely if linkages are established between the various resource inventories and research disciplines to enable data alignment, analysis and interpretation. Integrated systems analysis protocols can be run forwards or backwards to test the impacts of different drivers and assumptions on other components. For long term research and adaptive management this analysis can be useful for determining when assumptions, theories, modeling efforts or even entire research components should be dropped or modified.

2.3 Enabling Components of the Theme

Environmental sustainability research must be done in a deliberate, coordinated way. This section identifies a number of needs or resources which allow for better coordination of research - "enabling components" and must be available if research is to be successful. The section concludes with a list of research areas which should be considered eligible areas of research under the OMAFRA/UofG partnership even though they are not listed as research priorities under Section 3.

Capacity for foresight/scenario development

In order to set the context for all research and discover what research needs to be done, it is necessary to conduct scoping activities which look at future changes in global/national policy, economics and technology drivers, and to anticipate what impacts these may have on the future structure and nature of the agri-food industry and rural communities in Ontario. Examples of these changes over the last 40 years include the change from 300 to 3000 acre farms, removal of fence rows to increase field size, the increased installation of tile drainage, as well as the changes in the location of farming operations in response to urban expansion. Researchers in environmental sustainability can then investigate what impact these potential scenarios could have on natural resource quality and production sustainability. The description of future scenarios (e.g. in response to continued urban pressures, needs to protect aquifer recharge and wellhead areas, and climate change) would be relevant to beneficial management practice development and to guiding biophysical research.

Improved resource inventories (air, biodiversity, soil and water), interpretation and monitoring

A logical progression from scenario development (A) is to develop diagnostic systems which routinely integrate various land databases to assist in monitoring and recognizing trends over time in primarily the state resources (soil, water, air, biodiversity), but also in activity (agriculture census, farm environmental management survey) or other stressor (urban land use, climate) levels. Many of these diagnostic systems can be developed through research projects or by other agencies, but should be flexible to allow for adaptation to the specific needs of the Ontario agricultural sector and maintain them to support scenario analysis (A) and the policy impact assessment activities outlined in the following section (C).

As data from the existing inventories for soil, water, air, biodiversity and climate are integrated, and analyzed, the results will support environmental sustainability assessments by showing the spatial (and to some extent the temporal) relationships between the basic resource layers. These analyses will also reveal gaps and inadequacies in the existing inventories and help define the improvements required to support and document ongoing environmental sustainability efforts. Fortunately, at least in some cases, technology is being developed to rapidly improve the spatial and temporal resolution which can be measured. These inventories and interpretations should allow benchmarking and modelling both forecasting and backcasting so that we can see where we were in the past and project our likely path to the future with business as usual or with potential foresight scenarios. An understanding of "what we've got" in the province in terms of land base capabilities, e.g. for biofuels or bioproducts, or adaptation to climate change, is an important step in identifying constraints or concerns for today's or future farming systems. This information should guide the allocation of future research resources. The monitoring aspect is also important to be able to validate biophysical models on larger scales.

Research areas:

- Development of methods and models to extract data from the specific soil, water, biodiversity and air data holdings and combine them to create resource databases which are spatially and temporally integrated
- Development of statistical analysis and scaling tools for hierarchical analysis; descriptions and understanding of data/interpretation reliability and confidence
- Development of methods and models to integrate and interpret databases for measures and indicators against which to measure change and long term sustainability; researchers can help develop systems analysis capability
- Work with the sector, analysts and other user groups to design protocols and tools to evaluate the environmental impacts of changes in agricultural practice
- Development of methods and models to enhance monitoring and improvement of the resource inventories

Assessment of the impact of government environmental sustainability policy on the agri-food system and consumers

When new policies are envisioned it is important to predict the impacts on farmers, agri-food processors, rural communities, consumers and the environment. Once implemented it is important

to measure the impacts to confirm the policy and allow for adaptive management. Clearly, a substantial portion of this work will be done by OMAFRA in-house (for confidentiality reasons amongst others) in order to select which of the various policy options will be developed for implementation. This policy analysis activity will be highly coordinated with scenario development (A) and will draw strongly on the biophysical database diagnostics and modeling capability developed in (B). Information which comes from monitoring or research innovation also needs to be considered and communicated in the context of existing or needed policy. The nature and efficacy of both existing and proposed policies could be evaluated by researchers.

Research areas:

- Predicting and measuring the nature of environmental change brought about through policy; the research needs to be able to assess and communicate trade-offs that policy makers will have to make and the tools developed need to be amenable to this
- Surveys and behavioural research to look at adoption/change with particular tools, public versus producer priorities
- Develop criteria for future policy development – predictive, what works, what are constraints
- Development of innovative policy tools – jurisdictional scans, comparative analyses, regulatory framework research
- Evaluation of environmental policies e.g. education, regulation, taxation etc.

3: Research Areas and Priorities for this Theme

3.1 The Approach

This section sets out the strategic research areas which OMAFRA will champion for its research programs. They are presented in a logical, unranked, order. Specific research opportunities within a research area have been ranked as high or medium priority. The priorities for this research theme are articulated through five research areas. Each research area has a description and examples of key deliverables to be addressed. Biophysical, social and economic research approaches are encouraged where appropriate to inform agri-environmental policy, programs and initiatives.

3.2 Description of Research Areas

Priority Research Areas

A Enhancing agro-ecosystem resiliency/stability/productivity

Understanding of biophysical processes in the agro-ecosystem is needed to develop modeling and analysis at different scales in support of environmental sustainability. The key to enhancing productivity, stability and resiliency for land based agriculture is a better understanding of soil health within the agro-ecosystem. A systems approach can incorporate initial resource states, natural and human stressors, natural and behavioural buffering capacity, environmental

change, social/economic and biophysical consequences, and feedback mechanisms. Understanding of the agricultural land base as a system is important to determine indicators and ranges within which these systems are resilient and relatively stable, as well as tipping points when stressors cause a system to become unstable or deteriorate.

Benchmarks for sustainability will be specific to location and use of a soil; for instance a soil high in organic matter may be desirable for root penetration and water holding capacity, but enhanced nitrogen cycling may contribute to more denitrification and N_2O (a greenhouse gas) production. Connecting models in an integrated manner to concurrently assess soil, water, air and biodiversity responses, as well as multi-functionality, is a component of this research area. Improvements in production efficiency obtained by better understanding of the agro-ecosystem could also be a component of this research area to help producers optimize marginal returns from available resources while at the same time conserving resources.

Key Deliverables will be:

- Evaluations of how changing crop rotations and/or residue removal for bioproducts or on-farm energy production (e.g. used in anaerobic digestors, biomass combustion) impact on crop productivity, demand for and fate of nutrients and pesticides, soil ecology, nutrient cycling and carbon sequestration in Ontario
- Life cycle comparisons of bioproduct and alternative production systems to conventional production systems considering economics, GHG emissions, water use and quality, soil quality, pathogen and nutrients losses, land base, energy, input and transport requirements, etc.
- Measures, benchmarks and thresholds of agro-ecosystem resiliency, stability and productivity to monitor and evaluate impacts of practices and policies and to respond to drivers like climate change and intensification (greater production per unit land area)
- Evaluation of environmental impacts of production systems under predicted climate change scenarios. Assessment of changes that could be made to recommendations and best management practices to adapt to climate change
- Definition and delineation of the agricultural landscape to accommodate and optimize multi-functionality including production, habitat and water cycling (e.g. area of wetlands required for a particular function). Determination of the impacts of shifting production to marginal lands versus intensification and evaluation of the potential resource base for bioproduct and food production.
- Methods to acquire, develop and analyze agro-ecosystem resource databases (soil, water, air and biodiversity) cost-effectively to provide integrated resource inventories and measures against which to assess change and long term sustainability at different scales. Assessment of the means and policies for data sharing and availability to realize benefits to agriculture, food and bioproduct sectors and rural communities.
- Determination of value and cost effectiveness of enhanced monitoring and modelling options for improved resource inventories and interpretations of environmental change brought about through policy and practice implementation.
- Improved methods for and monitoring of agro-ecosystem processes over winter (i.e. nutrient and pathogen dynamics, gaseous losses) to validate models and make improvements to recommendations (e.g. tradeoffs between spring versus fall manure application)

- Determination of how the variability of the landscape impacts on the efficiency of the farm and farming practices. Determination of the environmental and economic advantages to adopting site specific, real time monitoring or other specialized approaches to managing inputs and practices.
- Understanding of how and what level of crop, livestock and other biodiversity contributes to the resiliency, stability, and productivity of the agro-ecosystem

B Improving water quantity supply and quality

Hydrology is the driver of productivity and pathway/fate of potential contaminants on the farm. Potential contaminants include nutrients such as N and P, soil particles, pathogens and other chemicals such as pesticides and pharmaceuticals. The role of various land uses and practices in changing the quantity, fate and pathway of contaminants needs to be understood and quantified. Concerns for water quantity and quality span many scales from farm to municipality to watershed to the Great Lakes basin.

Research focus on field and subcatchment level hydrology and hydrogeology, providing for scaling up and extrapolation of implications to watershed scale when appropriate and collaborations are available. Research is needed to characterize the biophysical variability and complexity encountered in moving from plot-scale to farm-scale hydrology and subsequent impacts on surface runoff, groundwater recharge, soil storage and land drainage. The implications of climate change for water management in the agri-food sector in Ontario need to be anticipated and understood.

Key Deliverables will be:

- Determination of the sensitivities of different agricultural production and food processing systems to water restrictions. Experimental analysis of scenario impacts of various water supply rules. Determination of the environmental and economic impacts of water restrictions to agri-food production (e.g. impacts of less soil cover, residual nutrients) compared to other water uses
- Development of a widely applicable methodology for identifying and mapping portions of fields and subcatchments in rural watersheds that constitute critical source areas for: i) surface runoff, stream sediments and associated contaminants, and ii) groundwater recharge, with particular attention given to winter and spring runoff conditions.
- Improved knowledge of seasonal and variable source area hydrology that can be used to develop, evaluate and validate management methods, such as riparian buffers, to control the transport of sediment, nutrients and pathogens
- Assessment of the potential for and impacts of various policy, formal and informal administrative arrangements and technologies for water management to overcome water supply constraints in Ontario for agricultural production and food processing (e.g. water storage ponds, scheduling on shared systems, water re-use)
- Improved understanding of agricultural drain ecosystems and functions so that field and rural municipal drains can be designed and managed to improve water availability and quality while retaining production benefits. Determination of the impacts of tile drainage on source area hydrology and groundwater recharge quantity and quality

- Validation of best technical and economically affordable water efficiency measures and water use coefficients for agricultural production and food processing. Linked to #4.
- New technologies for identifying and tracking persistence (or survival in the case of pathogens) and transport of agricultural contaminants to support understanding of on-farm hydrologic pathways and evaluation of management practices. Linked to #4.

C Managing air emissions from the agri-food system

Odour is the number one air issue for public attention and complaint from agricultural and food processing operations. Ammonia is a component of odour, a precursor to fine particulate matter ($PM_{2.5}$) and is listed as a toxic substance by CEPA, Schedule 1. Particulate matter is of increasing concern. Greenhouse gas emissions (carbon dioxide, methane, nitrous oxide) and enhancements to C and N sequestration, part of biogeochemical cycling in the agro-ecosystem, also fall under this area.

Key Deliverables will be:

- Evaluation and validation of strategies and technologies to cost-effectively reduce odours, greenhouse gases, ammonia and particulate matter emissions from agricultural production and food processing
- Validation of coefficients and parameters used in models estimating point and non-point air emissions and transport from agricultural production and food processing. Particular concern for emissions from livestock production and manure use, and fertilizer and agrochemical use.
- Quantification of the impact on human/worker health and animal health of practices to reduce air emissions from livestock facilities

D Developing, evaluating and validating Best Management Practices (BMPs)

This research area supports the development, evaluation and validation of best or beneficial management practices which are intended to have environmental or public benefit. This applied research should support the development of scientifically credible BMPs, recommendations and support policy development and regulations as appropriate. Validation refers to determining how a practice performs under a variety of circumstances, and requires replication of an experiment over several landscapes for a geographic distribution of impacts. A long-term assessment may also be needed to evaluate all environmental impacts. Evaluation and validation projects are desirable even though a practice may not be considered “new or innovative”.

There is a need to confirm that environmental improvements expected through BMP adoption are being achieved at different scales. On-farm or model farm research should be used as much as possible to assess practicality and improve the adoption of BMPs that are validated. Integrated systems analysis should be used to put the biophysical, economic and behavioural “pieces” together. Continued development, evaluation and validation of BMPs, including for purposes beyond those originally intended, is important to quantifying tradeoffs between soil/water/air/biodiversity impacts and environmental/economic/social aspects of a practice.

Study of combinations or systems of practices for different or multiple purposes is also needed.

Key Deliverables will be:

- Evaluation and validation of BMP practice/system effectiveness for multiple pathways, contaminants and purposes to determine additive or contradictory effects of different practices. Evaluation at different scales to determine and confirm both on-farm benefit and extrapolation to broader environmental and societal improvements. Linked to #5.
- Determination of the incremental benefits and cost of additional practices to most cost-effectively deploy/recommend BMPS for greatest environmental and production benefit. Potential areas of study include: how to best deploy BMPs to manage sensitive delivery areas and concentrated flows, how to best treat high volume, low nutrient effluents (e.g. greenhouse effluent, washwaters) for different end points (re-use, direct discharge, land application, sanitary sewer) and how to most cost-effectively monitor, manage and reduce pathogens while considering nutrient and other implications.
- Evaluation of producer behaviour and willingness to adopt BMPs and implications for policy and program development
- New methods and systems for nutrient recommendations that can better account for availability of nutrients from soil organic matter and land applied organic materials, environmental concerns, product quality and safety, and synchrony of release from organic sources and uptake by crops, in addition to most economic yields.
- Methods and tools to characterize organic materials and agricultural landscapes in order to assess risk (to soil, water, air, biodiversity and food safety) and recommend management options for land application of these materials

E Capturing added environmental/societal value from agricultural production and the agricultural landscape

In addition to the goods resulting from agricultural biodiversity (food and fibre production) which are already well recognized by society and have monetary value established through existing markets, there is interest in demonstrating and valuing the public benefits which the management of the agro-ecosystem provides. The public values environmental goods and services such as habitat, species protection, groundwater recharge and wetland filtering, and benefits to the producer such as agroecosystem resiliency and productivity which result from some adopted systems and practices. It is important to understand and quantify the underlying biophysical processes and to develop indicators of the required range of air, biodiversity, soil and water quality for production, so that the additional value or consequences for practices outside this range can be determined.

Key Deliverables will be:

- Definition and measurement of magnitude and distribution of benefits to private and public interests of different systems/practices at different locations and scales.
- Tools and measures to verify environmental goods and services provision in the agricultural landscape.

- Determination of the value of private versus public benefit, how these values vary by location and system, and how these differences could affect policy and program development.
- Assessment of the societal willingness to compensate agricultural producers for environmental goods and services by different mechanisms. Evaluation of producer behaviour and willingness to deliver environmental goods and services.
- Comparison of governance mechanisms and capacities required to implement an environmental goods and services policy for agricultural production in Ontario

Short Term Priorities and Criteria

Given current government priorities, if the situation arises, greater priority will be given to research which provides information: i) about the implications of climate change for the agriculture and food sector and ii) to validate the theories, models and practices underpinning provincial policies and programs (e.g. nutrient management, source water protection, species at risk, GHG offset, environmental goods and services).

4: Critical Success Factors

4.1 Success Factors Concerning Enabling Components

Capacity for foresight/scenario development: To be successful, foresight activities should involve consultation and stakeholder input, especially on the assumptions chosen. Scenario descriptions and projections will assist researchers in developing more relevant research proposals. The scoping exercise is iterative and should include both forward and backward projections. This work can be ongoing; however, it should annually support planning, goal and priority setting exercises.

Improved resource inventories (air, biodiversity, soil and water), interpretation and monitoring: Researchers work with the Federal and other provincial agencies which maintain, enhance, distribute and interpret spatial databases. Much of the effort at the Federal level in developing the National Agri-environmental Health and Reporting Program (NAHARP) indicators for national and international reporting for example is not at a level of detail relevant to behavioural change or to demonstrating effects of agricultural management or BMPs to the public at the local level.

The potential usefulness of the data needs to be defined and publicly communicated. It is not desirable that the data quality falls short because the multiple potential purposes were not imagined or identified. There is potential to use databases and monitoring at the research, policy and practice levels which needs to be directly applied and communicated.

Access to expertise such as pedologists who understand and integrate biophysical processes in the landscape needs to be improved internally and externally to develop, utilize and interpret these databases.

Assessment of the impact of government environmental sustainability policy on the agri-food system and consumers: Research must be conducted on policy impacts in addition to the knowledge and biophysical and economic modeling ability on which to make science based predictions about policy impacts. Researchers should collaborate with AAFC Agri-Environmental Policy Bureau to improve models used in policy development.

4.2 Success Factors Concerning Recommended Research Areas

Enhancing agro-ecosystem resiliency/stability/productivity: A long term approach needs to be fostered and supported. So far as possible, existing models should be used, adapted and validated for Ontario conditions. An integrated systems analysis approach is recommended to tie together all the components and in particular the biophysical relationships. It is not advisable to develop large all-encompassing models. Rather, use existing models which complement each other so that intelligent human interfaces can make appropriate and documented assumptions when linking model components. Model components can then also be improved and validated separately. A multi-disciplinary approach is required to do agro-ecosystem and integrated systems analysis with much expertise lying outside traditional agriculture disciplines. Case study or model farms should be implemented to analyze long term and system results.

Improving water quantity supply and quality: While recognizing there are linkages to larger scales, researchers should focus on water quality and quantity research and monitoring at the field and farm scales. Research is needed to characterize the biophysical variability and complexity encountered in moving from plot-scale to farm-scale hydrology and subsequent impacts on runoff, recharge and land drainage. Researchers should link on-farm to watershed research projects but should not be expected to take the lead in this regard.

Researchers also need to collaborate with other agencies to define levels of concern (standards/benchmarks) in water bodies for different purposes, i.e. human drinking water, ecosystem (most sensitive species), or for production. Researchers need to work with other agencies to define whether water body sensitivities are due to concentration (acute) or chronic (loading) aspects for different contaminants in order to set targets for systems and practices (zero discharge/risk is not possible in open, biological production systems).

Reducing air emissions from the agri-food system: Similar to the “Water quantity and quality” research area, air emissions and transport research relies on other agencies to determine the importance of sensitivities to concentration (acute) or chronic (loading) aspects for different contaminants in order to set targets for systems and practices (zero emission/risk is not possible in open, biological systems). Other agencies are also interested in larger scale models and health impacts.

The designing of appropriate institutional frameworks to allow air emission trading (carbon offsets) could fit here but may fit better under the “capturing additional environmental/societal value” research area and policy research themes. Again the underlying biophysical components, certainties and means of validation need to be established for trading programs to have a real difference in the environment.

Developing, evaluating and validating BMPs: BMP research generally represents the practical application of basic and academic research findings. Often it includes adapting or testing existing practices and is not considered innovative. Consequently, it does not meet publication or promotion and tenure requirements of academics and additional support may be required to ensure that the applied research step is carried out and documented. The research data underlying BMPs and production recommendations must be organized, documented and stored in an accessible fashion. This information supports acceptance and credibility of BMPs, provides a starting point for future modifications and will be called on when questions of liability arise.

There needs to be recognition of the public and industry service provided by this type of research. Industry and government must play a greater role in this area of research because of the practical and logistical/management requirements and large spatial and temporal scales of the work. For example there are Ontario Soil and Crop Improvement Associations spread across the province for which a partnership for on-going co-operation could be established. Large scale projects such as Tillage 2000 or Partners in Nitrogen have been developed under the OMAFRA/UofG partnership in the past. The projects can be designed so that adoption and efficacy can be monitored and public communications incorporated into the project. Partnerships can also be built with producers and agri-business since there are often direct economic benefits of the BMP research

Capturing added environmental/societal value from agricultural production and the agricultural landscape: When looking at valuing environmental goods and services, cost effectiveness needs to be considered, not just cost benefit analysis. The analysis must encompass the range of environmental and ecosystem goods and services including impacts on those which have an existing market system as well as those which are currently part of the general public good. The use of absolute values from cost/benefit analysis to make policy decisions about tradeoffs is cautioned.

Integrated systems analysis is needed because there is usually a range of environmental goods and services that must be accounted for. Often an environmental good or service “comes along” with some other production objective and it is critical to understand the underlying biophysical relationships.

The inventories, interpretations and monitoring of the air, biodiversity, soil and water resources are also important to make the additional markets work because the quantity and quality of the resources, goods and services available needs to be known in order to substantiate trading. However, it is OMAFRA has not made this area of research a significant priority.

5: Other Related Considerations and Recommendations

5.1 Considerations

Research results inform government policy and influence industry practices in Ontario. Therefore, reports and other methods of communicating research results to OMAFRA and stakeholders are expected. It is recognized that most of these additional considerations may overlap with other themes (e.g. Agricultural and Rural Policy). The translated research results could take the form of:

- Advice on the potential application and use of the knowledge gained, i.e. does new information indicate that a different decision should be made; policy, programs or tools are endorsed or should be reconsidered?
- Advice on emerging issues and innovations and future action needed.
- Understanding of real versus perceived risks, and relative risks between issues and land management options (Risk = *f* (magnitude, likelihood, uncertainty)).
- Changes in understanding (scientific, economic, environmental) or level of certainty of effects that could influence sector or government decisions.
- Incremental benefits and costs (environmentally, socially and economically) of applying findings or implementing recommendations.
- Holistic comparisons of options on a life cycle or multi-functional, agro-ecosystem basis.

It is recognized that most of these additional considerations may overlap with other themes (e.g. Agricultural and Rural Policy) and may also be related to knowledge transfer and translation initiatives under the OMAFRA/UofG partnership.

FOOD FOR HEALTH

1: Description and Scope of this Theme

1.1 Theme Description

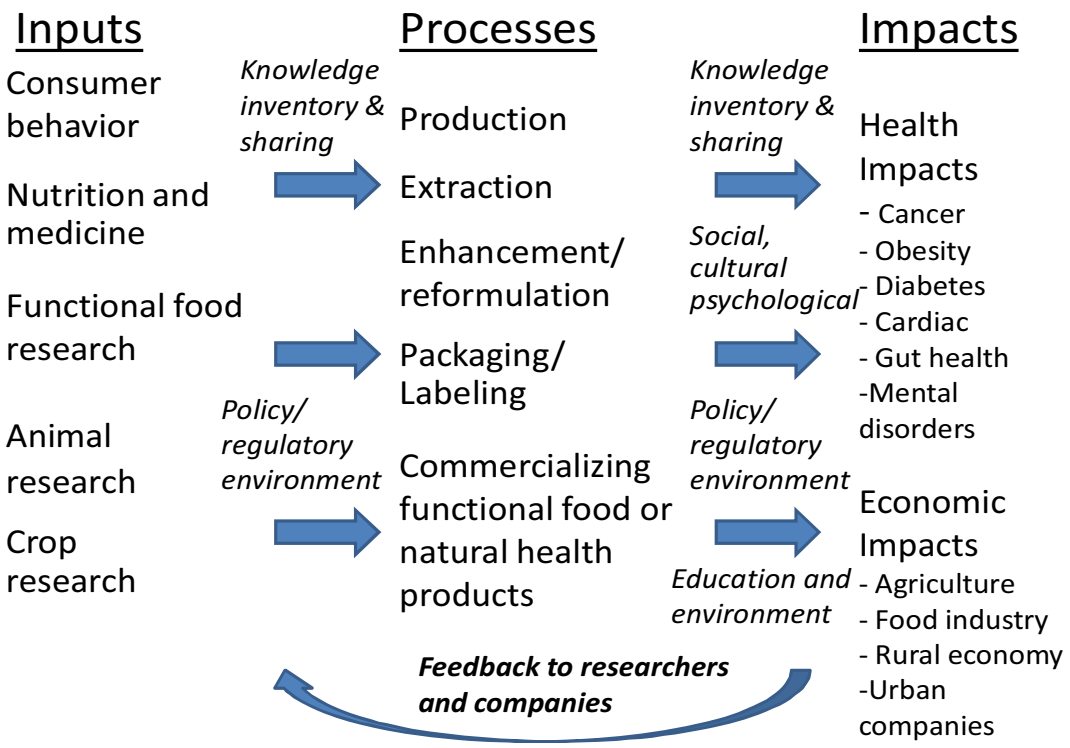
The opportunities for the agriculture and food industries to contribute positively to the health of society are considerable and increasing as the knowledge related to the potential health impacts of food grows. The Food for Health theme is intended to help guide the OMAFRA research agenda to address the significant potential to improve health through food. A successful research program, from consumer research through to food production and formulation, cannot only change the health of Ontarians; it can provide economic opportunities and competitive advantages for Ontario agri-food companies and producers. The research scope is large and complex but the potential social and economic payoffs from food for health research are far beyond those usually found in agri-food research alone.

1.2 Content Components of the Theme

There are several key components identified in the figure. The sciences of genomics, medicine, nutrition, food and agriculture form the scientific core of the theme. However, achieving the health and economic objectives of the theme will require research beyond the core sciences. Understanding consumers, their dietary patterns and the choices they make about food is an essential research component. There are also many areas in policy and the economics of food and health that must be part of Food for Health research theme.

The process of creating healthy foods and their adoption by society involves many types of research and a variety of activities as illustrated in Figure 1. Initial research must be translated into new food products. This can involve new extraction and processing technologies, new formulations and new packaging methods. The ultimate impacts of healthy foods depend on consumer purchasing decisions, dietary patterns, the ability to influence adoption by consumers and numerous social and cultural influences. This occurs in an environment affected by knowledge sharing and the regulatory and investment environment.

Figure 1: From Research to Health Impacts



Core components for the food for health theme

1. Societal and environmental drivers for food for health.
2. Consumer behavior in several areas:
   a. Dietary patterns and purchase decisions.
   b. Acceptance of novel food products particularly genetically modified products.
   c. What societal changes are needed beyond decisions at the individual level?
3. Actual linkages between food and health and how food impacts long-term health and healthcare costs – evidence based.
4. Bioactives and food profiling.
5. Food processing and food for health.
6. Economic implications for farmers, rural communities, agri-food companies, and employees across Ontario.
7. Development of highly qualified personnel and research capacity in Ontario.
8. Barriers to innovation in food for health.

9. Capabilities to commercialize healthy food products in order to obtain the economic and social benefits from research efforts. Technology transfer, investment, a supportive regulatory environment, and people trained in both the business and science of food for health, are all necessary factors in making this happen.

2: Context and Background for this Theme

2.1 Context and Background

Recent research advances in food, nutrition, and medicine, have enhanced the understanding of the relationships between food and health in the research community and in the broader society. Food has the ability to affect health both positively and negatively. Therefore, the motivations for undertaking this food for health research are significant and multi-dimensional.

Positive impacts

There has recently been a great deal of new evidence on the benefits of certain foods – from fruits, vegetables and grains to coffee, fish, meats and even chocolate, in moderation. The development of new functional food ingredients offers the potential to improve the overall health of the population. However, the research and commercial activities that will take functional food products to consumers are both in their early stages of their development. Canada lags behind other parts of the world in supporting and building this industry, in part due to a less than supportive regulatory environment. There are significant opportunities to acquire new technologies and knowledge from researchers and industry around the world to support this theme.

Dietary patterns are major drivers in determining the impacts of food on health, improving healthy food choices while offering major opportunities for health improvement. Evidence of the impacts of diet on health is in the early stages of development. Future developments in both research and policy must be based on solid scientific evidence*.*

Negative impacts

Food can negatively impact health in many areas. For example, obesity is reaching epidemic proportions in North America and Ontario is not immune. Sixty percent of Ontarians are overweight or obese. The causes of food related health issues are much broader than simply the food products themselves. These determinants are not only biological in nature, but include social, cultural, and environmental dimensions, which operate at multiple levels across a person's life span. Risk reduction of most chronic diseases by diet alone is therefore limited. Change must be made at the societal level as well as the individual level. The research, regulatory and policy needs are beyond the science related to food and health alone.

A significant factor is consumer purchasing and consumption patterns. There is no doubt that part of the problem rests with the individuals suffering from obesity; over-eating, consumption of calorie and fat rich foods coupled with sedentary lifestyles are major contributors to the problem. However, food formulations and ingredients, as well as portion sizes, may also be contributing factors. While

the food industry has begun to respond to the challenge, their response has been inhibited by an inadequate use of knowledge related to alternative ingredients or formulations, consumer resistance to new products, concerns over cost competitiveness or an unwillingness to change. New research into consumer behavior can help understand why Canadians aren't following the Canada Food Guide and why they maintain unhealthy buying and eating behaviours.

Food choices contribute to many other chronic disease conditions like diabetes and heart disease. High salt levels contribute to hypertension; trans-fats have been linked to heart disease as well as to obesity. There are health concerns related to food packaging and linkages of certain chemicals to cancer as well as their impact on the environment.

Social

Social and cultural influences are important contributors to health problems associated with food and health. Diet, education, and consumption decisions all play a role. The social and economic costs of health problems associated with food (and inactivity) provide a powerful incentive to undertaking food and health research under the OMAFRA agreement. Provincial government's spending on healthcare has increased at an average rate of 8.4 % since 2001-2002. In 2007 healthcare consumed over 40% of the 2007 provincial budget. More worrisome was the fact that increases in healthcare costs consumed 65% of increased government revenues for 2006 and is projected to consume 75% of 2007 increased revenues. This trend will continue in the immediate future with healthcare consuming an ever-increasing share of the provincial budget.

There is significant potential to reduce chronic and short-term illnesses among Ontario citizens and improving the overall health of Ontario's society food for health. In 2000/2001, obesity cost Canada's healthcare system an estimated $4.3 billion: $1.6 billion in direct costs (i.e. hospital care, drugs, and physician services); and $2.7 billion in indirect costs (i.e. lost earnings due to illnesses and premature deaths associated with obesity) (Katzmarzyk *et al*, 2004).

Economic

There are opportunities for Ontario agri-food supply chains at all levels to create new products in the area of healthy foods and to reduce the economic costs of health-care for businesses and governments. Food for health provides an opportunity for Ontario farmers to differentiate themselves from competitors.

Building capacity for future research and economic development

This research theme will support the development of new research capacity in the many areas that play a role in the food for health theme. It will also help to develop the highly qualified personnel needed to support government, university, business, and NGO organizations in the future.

Fostering communication and adoption of results

One objective for OMAFRA funding should be the creation of an environment that will foster the exchange of research and innovation. Research results need to be shared within the academic, scientific, agri-food, and health communities to increase overall comprehension and linkages. There are many groups working on many related aspects of the food for health theme. Connecting

researchers around the province and around the world and acquiring knowledge from existing studies being done in other regions are fundamental necessities for success in this large and complicated field.

Sharing research findings with the agri-food industry and with agricultural producers will help them identify ways to differentiate Ontario products from those in other regions on the basis of health. Many of these ideas can be communicated directly in workshops, and newspapers and electronic media.

Food system issues

The global food system is changing rapidly and research to be relevant must focus on the world of the future. Issues like genetic modification of food and the use of nanotechnology in food will challenge the agri-food industry of the future. An increasingly active local food movement is countering the move to global supply chains. The cost of current energy sources, emerging alternative energy technologies, environmental sustainability, and other issues will shape the industry of the future. Health has to be woven into all aspects of the fabric of this continually evolving industry.

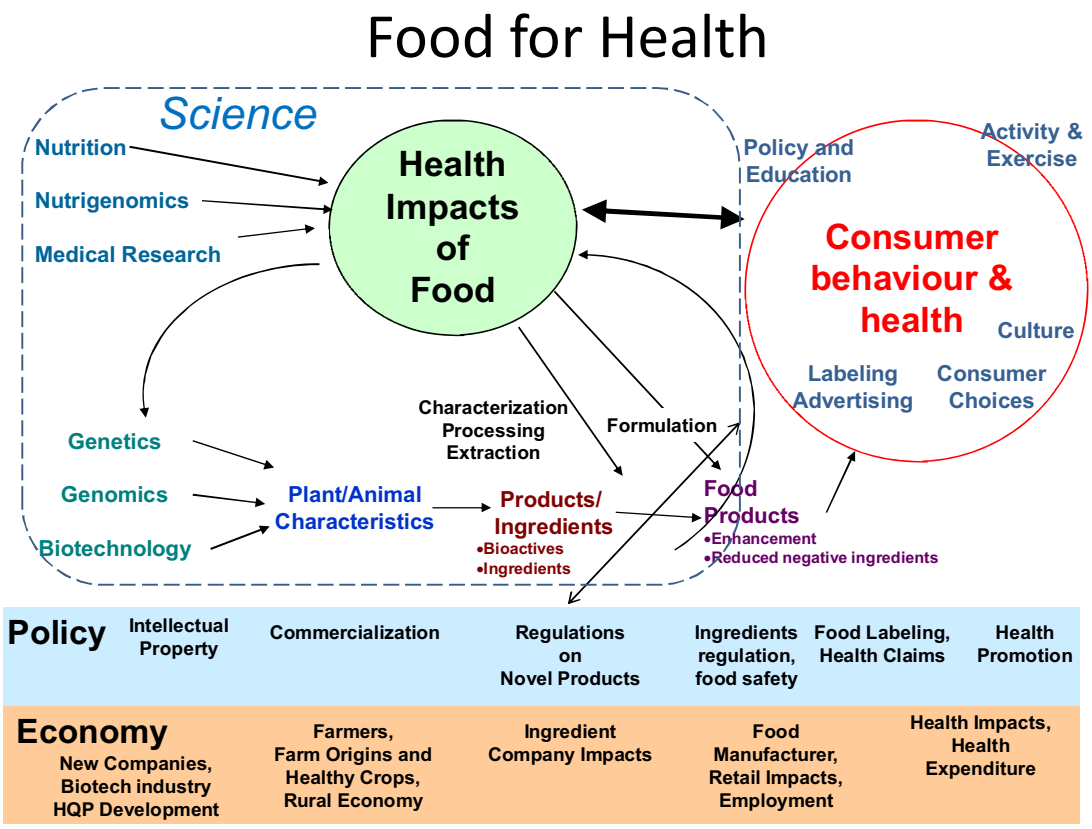
2.2 Key Assumptions

Overarching Assumptions for this Theme

The relationships between food and health are complex and multi-faceted as illustrated in Figure 2. The theme must incorporate major efforts in understanding consumers and consumer behaviour. Panel members were clear that any research must be based on sound science and develop solid evidence of health benefits so that claims can be scientifically substantiated for consumers. Investments in this theme offer potential payoffs in economic and social returns. In some cases major gains may be achieved with relatively small investments.

Much of the research needed to change the health profile of Ontario food products is being done in other research networks and often in other countries. Linkages between medical institutions, food and agriculture researchers and industry will be critical. New technologies could lead to significant improvements in the ability of food to positively affect health; so too will new models of consumer behaviour and policies to support better eating habits.

Figure 2: Conceptual Model of Core Components of the Food for Health Theme



However, these models will have to go beyond the individual. Cultural differences, eating environments (home, restaurants, cafeterias, etc.) as well as where we purchase foods influence choices related to healthy foods. More than forty percent of food expenditures are for food eaten outside the home. A better understanding of these socio-economic influences on food and health must be incorporated into research and strategies for actions.

Impact of regulations on innovation and product development – Regulations typically enforce conformity and hamper the development of innovative new products, particularly in small volumes. The slow regulatory approval process and the fact that it sometimes takes years to adopt in Canada existing knowledge from other countries hampers businesses from marketing innovations to consumers. This issue was repeatedly identified in the comments and is a significant potential impediment to moving the agenda of developing and promoting new healthy food products. Regulations at every level of government act as an impediment to innovation and it will be essential to understand how to continue to protect the public while encouraging new products that may improve public health.

A growing area of concern for food business is the increased pressure by municipalities and provincial governments (i.e. City of Toronto and Province of Ontario and reduction of trans-fat) to develop regionally specific product requirements. For national and international companies in

Ontario this is a significant challenge that can drive up costs and impede release and adoption of health food products.

Healthy foods and health premiums – There is an assumption that there will be unique markets for health food products and that many of those markets will offer price premiums associated with new products identified as "*healthy"*. Multinational food companies have recognized and are using the selling power of "health".

Cross-disciplinary nature of research – The topic is complex and draws on many disciplines, including consumer behavior, agriculture and food production, biotechnology, policy, nutrition, sociology and medicine. While some research may be accomplished within a single discipline, much will have to be done with multi-disciplinary teams. For clinical trials there is a need to link with medical research systems. There will be opportunities for Ontario universities, colleges, and the agri-food industry to participate in this research.

International markets and companies – There is a great deal of knowledge and existing research around the world, particularly in many of the large multi-national companies. Tapping into their knowledge base for the benefit of Ontarians should be a priority.

2.3 Trends

The feedback on trends recommended supported broadening the scope to include many of the broader global trends affecting the industry and society:

- A growing awareness among consumers and industry about the potential for food to impact health either negatively or positively.
- Changing global food systems and the impact of energy and the environment. Concerns over environmental sustainability, rising food prices, food shortages and food security in many countries.
- Consumer attitudes to new technologies and their potential distrust of new technologies used to change foods.
- Societal population trends particularly with respect to an aging population in Ontario and to the changing demographics of the population with respect to ethnicity.
- Declining rural populations and economic activity.
- New production and distribution systems – the growing movement toward organic products and local food systems. Concerns over the safety of products from other regions and their environmental sustainability.
- Continual escalation of chronic health problems and the societal and economic costs associated with them.

2.4 Opportunities

Ontario has all of the necessary elements to create a strong food for health research program and to turn new knowledge and discoveries into commercially available products for consumers.

- Ontario universities have research capabilities capable of improving the inputs and processes of an effective food for health strategy and in assessing the outcomes to provide feedback for improvements to the strategy. For example, the Advanced Food and Materials Network (AFMNET) provides linkages between the University of Guelph and many other research institutions in the area of food for health. MaRS and MaRS Landing are making the link between medical and agri-food research.
- Ontario's varied agricultural industry has the ability to produce most inputs for food for health products and the willingness to invest in new healthy opportunities for their industry.
- Ontario food processors produce 40% of food manufactured in Canada. The organizations and companies in this $33 billion industry are committed to health as part of their innovation agenda in the industry's recent strategic priorities.
- There is already a significant amount of research underway; much of it supported by private industries.

2.5 Issues and Barriers

Assumptions:

- Absence of a clear long-term strategy and commitment to connect the mandate of Agriculture and Food to health and well-being
- Lack of consistent long term funding.
- Lack of understanding of the factors that motivate consumer buying and consumption decisions.
- Lack of education programs concerning food for health.
- Difficulties in measuring inputs and collecting evidence. How much evidence will be necessary for health related claims?
- Changing government policies, priorities and regulations.
- Lack of qualified personnel to engage in research.
- Regulations at all levels of government.
- Consumer behaviour which resists better eating habits.
- Resistance to new technologies, particularly in some exports markets.
- Lack of sharing of knowledge among researchers, policy makers, industry, and consumers. Medical researchers and practitioners are not always receptive to ideas from agricultural, food and nutrition researchers.

2.6 Enabling Components of the Theme

- **Strategy** - a clear long-term strategy for developing Ontario's capabilities, knowledge and action for improving health and well being through food and for developing the industry to support food for health. *(What can we do better with which Ontario grown/manufactured product than anyplace else in the world and how can we communicate that excellence to consumers?)*
- **Knowledge sharing and linkages** - There is a great deal of data, research, and knowledge concerning food and health in knowledge networks around the world. With limited resources, it is important to link to external networks, particularly in Canada, to avoid missing important findings or information, to create research partnerships and to avoid duplicating existing research.
- **Social factors related to food for health -** *"The sociological or behavioural question of how to influence eating habits."*

2.7 Dependencies and Linkage with the Theme

- **Consistent long term funding** - Solutions and impacts will be long term. Therefore the strategy and execution of research around food for health has to be long term, as does the commitment by funding agencies to the theme. Without long term support the research will not achieve its potential impact.
- **Linkages** to medical, nutrition and health researchers, and clinical studies to provide the evidence of efficacy.
- **Policy linkages** – linkages between OMAFRA and other ministries in the Ontario government and across Canada to address a common and critical issue and to share resources.
- **Linkages to industry researchers and to industry research and knowledge** – Can we develop partnership strategies to gain greater access to proprietary industry research?
- **Adequate research capacity –** The availability of people and systems for measuring food components and consumer attitudes. Can capacity can be extended by linking to other research groups and institutions in Canada and abroad and by linking to industry.

3: Research Areas and Priorities for this Theme

3.1 Description of Research Areas

A Agriculture and food for health

Changing and improving the health profile of Ontario agricultural production. Ontario agriculture and food industry can be leaders in producing, promoting and ultimately profiting from products that are healthier for consumers. Human health can begin at the farm gate.

Research in this area is a high priority and will fall largely within OMAFRA's research mandate. Programs in this theme include:

- Research into healthy farm products to differentiate Ontario products and to attract the consumer.
- Communicating the health value of foods.
- Improved understanding of linkages between production practices and human health. How do on-farm practices affect food and impact human health.
- Role of new production systems like organic and local food systems in improving human health.
- What impact will a healthy food strategy have on farmers and rural Ontario?
- What role should farmers and farm organizations play in promoting health in developing new products and in commercializing them.
- Sustainable production, resilience, and research on building diversity and decentralization in the food system as a barrier to a sustainable production system.
- Local food systems and policies with respect to buying local – How will we ensure that the food included is healthy throughout the year?
- Urban agriculture systems and the impact on health.
- What impact will climate change have on Ontario food products?

B Bioactives, functional foods and new healthy food products

- Improved understanding of the bioactives in food and their health impacts.
- Improved ability to enhance and control the components of food to improve health related attributes through bioactive functional ingredients.
- Improved extraction and delivery systems for functional ingredients.
- Food processing and healthy food products – how can the health profile of processed foods be improved?
- Identifying bioactive food components for optimal human health using nutrigenomics.
- Bioactives ingredients in food products.
- Commercialization of healthy food products.

C Consumers and healthy choices

This is a high priority but it cannot be done by OMAFRA alone. Linking to other ministries, other funding agencies and researchers is critical.

- Understanding consumer behaviour and the determinants of unhealthy eating patterns - How consumers perceive healthy food products? What are their attitudes toward new products and new technologies? Impacts of pricing, packaging, and promotion?

- Dietary patterns, social influences (ethnic) on food, barriers to change and design of programs for children and adults. How is the Canada Food Guide used by Canadians? Nutrition communication strategies. Economic factors that influence food consumption.
- Developing policies and strategies to support healthier choices by consumers and to create new health focused societal models of behaviour.

D Understanding linkages between food and health

There is a great deal of foundational research into food/health linkages that must occur in medical, nutritional and health research communities that is organized and funded by other medical researchers. Much of the research will be done in other communities and linking with OMAFRA research is important. It is critical to improve the understanding of the relationships between food and health and all of the factors that affect these relationships.

- Food and disease prevention – What food items affect which disease conditions? Research into nutrigenomics, antioxidants
- Standards of evidence for research into the linkages and making health claims to ensure that claims are evidence based.
- Food profiling methods and systems – developing a system for signaling the health profile of products.
- Social, cultural, and psychological relationships between food and health.

E Policy, regulations, investment, and the economy

It is critical that we review the effect that policies, regulations and research funding have on the development of new niche products and markets.

- Regulation and the impact on food for health innovation – Regulatory barriers to healthy food innovation. How can regulators be more involved in learning about the research from the theme and in encouraging healthier products?
- Effective policy and regulation that support the development, commercialization and adoption of healthier food products.
- Creating a functional food industry that is built on a solid knowledge base and that is globally competitive.
- The economics of food for health - Are there potential savings for the health care system? What impacts could the theme have on Ontario's economy? Will those impacts be on rural Ontario?
- Investment challenges for healthy food innovation.

4: Critical Success Factors

4.1 Description of Critical Success Factors

Strategy for Food for Health - Because of the size of the issue of the relationship between food and health, the panel felt that the essential starting point for OMAFRA was a strategy around its contribution to food for health and the role of research in that strategy. This strategy may be partially based on foresight research with respect to food, health and the environment.

Linkages to other researchers, health networks and to other ministries – As pointed out earlier this initiative cannot succeed without several types of linkages

- Research linkages to share the developing knowledge in all areas from consumer to medical research. Create an inventory and evaluation of current research and progress toward goals identified in the strategy.
- Industry linkages to increase OMAFRA and researcher understanding of the challenges and opportunities facing industry and as a vehicle for translating research into products for consumers by commercializing new healthy food products. Make research results available to industry for commercialization. Include Ontario's agriculture and food industries in the research agenda.
- Government linkages – to translate research into policies and programs designed to support the theme

Consumer research as a fundamental knowledge base - Food is a consumer driven commodity and the choices made by consumers are based on a complex set of factors; understanding these and working with them is critical to success.

Focus on Ontario advantages – While the research should be focused on Ontario advantages it should pull good ideas from anywhere in the world. Application of global research locally – develop linkages with those R&D locales globally that are at the forefront of research.

Support for commercializing new healthy products – To be successful, healthy food products must be adopted by industry and consumers. Without research understanding the factors that contribute to commercial success and support for commercializing healthy food products the theme will not achieve its social and economic potential.

Capabilities or access to adequate capabilities in scientific measurement - In order to have the consistent quality products, there have to be standardized analytical methods to determine the quantity and quality of the health-benefiting components.

PRODUCT DEVELOPMENT AND ENHANCEMENT THROUGH VALUE CHAINS

1: Description and Scope of this Theme

1.1 The Approach

Research and innovation in relation to value chains encompass, though are not limited to, food product development and enhancement; the utilization of waste streams; market analysis and consumer behaviour; the increased demand for, and extraction of, high value functional ingredients; traceability technologies; and quality & safety assured supply chains.

The definition of 'value chain management' is the purposeful action of businesses operating along the value chain to utilize their combined resources and capabilities to achieve commercial outcomes that would be unattainable if acting in isolation. Innovation is recognized as one of the most important contributors to economic growth. Co-innovation occurs when multiple sets of individuals (businesses) situated along the value chain are able to conduct and implement leading edge innovations through possessing the ability to share information, learn and create new knowledge from that information, then act upon it in unison or systematically at multiple levels of the chain.

1.2 Theme Description

The product development through the value chain theme focuses on the philosophy and strategy for encouraging and managing value chains with an emphasis on developing products through a consumer pull process.

1.3 Content Components of the Theme

Value Chains are not only about product development. Process improvements are an important area related to overall productivity, profitability, innovation, as well as sustainability, and are all important areas for future research.

Value Chains do not need to be formal, with contracts - organizations can just "*do it*".

- It is important to have clarity and structure between partners regarding organization and governance. For example, who is responsible for what, how will success be measured and shared, etc.
- There must be mutuality in the decision making process for trust and open communication to be maintained.

- For many organizations, the more formal an arrangement is, the less certain it is that organizations will want to participate.
- The product development process within a value chain may more easily be overcome by addressing barriers, such as:
  - Distribution issues. For example, most large grocery retailers only order via a central distribution centre. Therefore, a consumer need or desire to "buy local" may be hindered by the inflexibility of an existing ordering process.
  - Additionally, large chain stores can't sell small amounts of local meat, unless it is from a federally inspected plant.

2: Context and Background for this Theme

2.1 Context and Background

Product development and value chain research are complementary to each other, but the two areas are not always connected. Much research could be done on Value Chains related to effectiveness and efficiency that are unrelated to product development. Conversely, the overall process of product development and enhancement, and the processes of individual members of the chain, could be vastly improved without necessarily having a new product as the immediate result.

Research need to be more closely aligned with industry, which will enable businesses along the value chain to adapt to market (consumer) demands more than is currently the case. Product developers and the scientific community need to connect much earlier in the process, enabling a more proactive than reactive research culture. The current method for research should be inverted, "*industry to involve researchers early in the innovation process. Industry leads…researchers support",* with the exception of basic research.

Stronger links between research and industry within a value chain would also bridge current information and communication gaps between the scientific and commercial sectors.

The goal of the research and innovation process must be to create a more successful and profitable agri-food industry in Ontario. Achieving this requires a conscious acknowledgement of the following:

The capacity for agriculture and agri-food to innovate in accordance with market opportunities stems from management capability, as well as workforce training and education. However, this capability is often the resource most lacking in the development and sustainability of successful, closely-aligned value chains, which are able to continually adapt to consumer demands and customer requirements through innovations in process, product and service. This has become a major factor on the processing end – in fact it is at a critical stage affecting the competitiveness of the industry.

- Well functioning value chains can provide a means to this end;
- Research goals need to be explicit and more closely linked to business;
- Agri-food must be in relationship with additional sectors (health, environment, etc) to take full advantage of opportunities.

2.2 Key Assumptions

- The goal of all research should ultimately lead to the improved competitiveness of agri-food in Ontario, partly through recognizing the increased influence of value chain business approaches on international competitiveness.
- Many value chains are already "*there and working*".
- All product development does not need to create something entirely novel; product enhancements or evolutions are also successful and profitable.
- By nature, value chains are specific but we need research to pull out best practice principles that apply to the many, rather than to the specific [such as varieties of soybeans developed and grown for individual target customers]?
- In developing a value chain, the earlier in the process producers are involved in the business decision making process the better. Incentives and leadership at an early stage will reduce adversity in a working relationship.
- While value chains are useful tools for improving competitiveness, they are not panaceas and cannot provide answers for every problem.

2.3 Trends

a) Consumer Segmentation

Most fundamental is that consumer segmentation is occurring, and each consumer segment often seeks products with specific attributes. This is the motivation for product development and enhancement. In addition, it is often a motivation for value chains because there is often a need to supply, and preserve the identity, of specific attributes through the chain.

That value chain related research lies at the forefront of international business and management research was not opposed by the Panel. However, there exists some disagreement in what exactly a value chain should look like or how it should be described. One Expert Panel member expressed, "*I like the word co-innovation more than value chains*."

Ontario suppliers need to anticipate and respond to preferences of consumer segments more effectively than in the past. To do so, a consumer pull attitude needs to develop.

b) Need for a commercial environment free from "interference"

Value chain alliances require the creation of a commercial environment in which collaborative partnerships can form and prosper without interference from external non-value-adding agencies and institutions.

One example of what is meant by "interference" is 3rd party institutions, such as marketing boards, that do not operate proactively in relation to the overall competitive environment, thereby limiting the creation and capture of value from consumers' perspective. This does not necessarily mean such boards or legislation should be abolished. Rather, it may simply mean they, or the related legislation, need to be modified to motivate/enable more market-focused innovation to occur along the value chain. In Ontario, the regulatory environment may go too far in correcting for market forces at times, and is an issue facing businesses situated along the value chain.

c) Deregulation

Global deregulation will bring ***increasing pressure*** for deregulation in Canada, where the trend to date has been more rather than less regulation. In either case, regulatory changes mean that scientists and researchers need to work directly with commercial businesses, and take account of the entire value chain throughout the entire innovation (and commercialization) process. Current/past policies and legislation are too often a barrier to innovation.

2.4 Opportunities

The opportunities for product development and value chain research arise from the aforementioned trend toward the consumer segmentation and from the opportunity to enhance market efficiency by reducing transactions cost through better coordination within the value chain.

These opportunities are not limited to just farmers and food processors, but to all actual and potential participants in a value chain, i.e. input suppliers such as packaging, seed machinery, or research suppliers. Value chain and product development research offer immense economic opportunities to individual businesses and regional economies

2.5 Issues and Barriers

Issues

a) Need for Industry and Research to be more consumer focused

Industry needs to react more effectively to consumer trends and demands than it currently does. North American commentators have stated for more than two decades that, through fragmenting into specialized value chains, businesses operating in the agricultural and agri-food sector may be able to create and capture greater value from the array of opportunities offered by a changing consumer market.

b) Inefficiency of Innovation and Commercialization

Technology has no value until it is commercialized in some way. This requires the creation of a business model that mediates between the creation of technology as an input and the creation of economic benefits as an output. Unfortunately, many innovations which make their way down the pipeline, do so slowly and with insufficient resources/coordination to extract full potential from the market and provide participants with significant commercial benefits. The challenge with research is the lead time. If research is reacting to an opportunity then, by the time there is commercialization, the market may have changed. There is a need to anticipate.

More effective commercialization could occur within a functioning value chain: particularly compared to that which would occur in the adversarial transactional-oriented environment that typifies the agricultural and agri-food/product sector. Alternative business solutions might provide an equal, if not superior, opportunity. This does not negate the possibility that innovation can occur in other forms of business organization.

Innovation will not occur unless it is profitable at all components of the value chain. Therefore, it is important that research processes allow intellectual property to be obtained and retained by those who cause the innovation.

Barriers

a) Business Processes

Two forms of processes occur in a value chain – Physical *(product flow)* and Virtual *(information).* The effectiveness of business processes is affected by factors that are internal and external to the individual businesses and/or the chain.

While product development is the focus of many innovation initiatives, the business-level processes that exist along agriculture and agri-food value chains can be so ineffective that they limit competitiveness.

b) Policy & Legislation

Traditional agricultural and agri-food related policy and legislation often acts as a barrier to innovation. Greater attention needs to be given to creating an environment that fosters consumer-focused innovation as core to the agri-food sector's development. For example, Ontario cannot afford to have situations in which a variety of wheat that was bred in Ontario for a specific food processor has to be grown in the U.S. (with a premium paid to farmers) because current legislation forbids it to be registered in Ontario or Canada.

If incorrectly aligned with the needs of the overall value chain, industry structure, policy, and legislation can have detrimental effects on enabling and motivating market-driven innovation.

2.6 Enabling Components of the Theme

For a successful value chain, the enabling components are:

- Trust;
- Good management skills;
- Confidentiality;
- Communication – constant and regular;
- Market info (consumer driven information);
- Strong leadership, with senior management buy-in;
- All parties must benefit.

For successful product development and enhancement, the enabling components are:

- **A need for good science;**
  - What technology is available? There is a need for leadership and enablers to make a better connection and create links between science and industry.
  - How are structures formalized so that this "enabler" can be efficient? Currently "enablers" for the business sector exist as brokers. The question was raised how government and science should partner within such existing processes rather than compete or negatively affect existing processes.

- **Market Intelligence (Knowledge of consumers and trend setters);**
  - How can research and organizations anticipate, rather than react to, consumer trends? It was agreed that if/when business organizations spend their own resources on research; it is more likely to be in anticipation of a consumer demand.
  - *"Innovation is industry led and public research supported."*
  - *"[OMAFRA-funded] research must work directly with business if Ontario is to compete on a global scale."*
- **Competitive Culture;**
  - The question was raised about how OMAFRA research, via the University of Guelph, can adapt the culture to better support an integrated system/partnership culture and, in doing so, encourage improved competitiveness.
- **Leadership;**
  - There must be visionary leadership and champions at senior levels throughout the innovation and commercialization process to ensure success.
- **Trust;**
  - Organizations in a properly functioning value chain share risk. The goal of a project cannot primarily be about a ROI for OMAFRA as this goes against the whole openness/trust issue associated with successful value chain relationships.
  - A completely open dialogue between businesses and researchers is needed but difficult to achieve because of the competitive nature of business and research development.
  - Openness can only exist in a managed relationship where confidentiality is guaranteed.
  - How can the relationship be managed so that a retailer is able to openly translate their needs back to OMAFRA and remain confidential?
- **Capacity.**
  - Relating to research and funding

2.7 Suggested Model for Product Development through a Value Chain

The following business model was developed as a useful tool for guiding product development through a value chain. It is considered a good example of the ways in which market intelligence could be gleaned and shared, and connections between new technologies from the University of Guelph might be commercialized by a business partner in a value chain.

Figure 1: Product Development Business Model

Business Development	Market assessment and potential Potential costing/pricing Competitor assessment Process evaluation Value Chain evaluation (include researchers and suppliers as relevant) Final decision on project viability & strategy
Product Development	Develop formulae, attributes Prepare spec package
Packaging	Determine packaging options
Negotiation	Prepare bid package for potential manufacturers/participants in the value chain - specific contract / costing level
QA Product Development Summary	Evaluate bid sample submissions
Packaging	Finalize packaging & labelling design
Product Development	Conduct plant trials
Design	Develop & finalize package design, graphics, etc Obtain necessary label approvals
Business Development	Finalize supply agreements, contracts, licenses
QA Product Development Approval	Evaluation of first production runs
Go to Market	

2.8 Dependencies and Linkage with the Theme

All the other themes need to be integrated into value chain theme, especially Emergency Management and Food for Health as they relate to product development.

3: Research Areas and Priorities for this Theme

3.1 The Approach

While product development and value chain research complement each other, research would best be served by creating two distinct subject areas, sharing equal importance.

i. Product Development

ii. Value Chains

OMAFRA research should have an increased focus on consumer needs in developing value chains and in creating new products as well as innovative uses for existing commodities. Examples include organics, regional agricultural promotion, natural health products and environmental goods and services.

- Does this research contribute to Ontario's agri-food competitiveness?
- Does this provide a sound base for relevant policy and regulation development?

3.2 Description of Research Areas

Product Development Subject Areas for Research

Following the model in Section 2 above, before specific research begins, there should be a business assessment (including an analysis on potential ROI), to best understand the benefit to Ontario by spending research dollars in any potential way. Conducting a business assessment first should also serve to clarify which research projects are of a higher priority.

A Product Development and Enhancement

All product development doesn't need to create something new or trendy, but rather could relate to enhancing existing products.

- Novel foods with specific health traits;
- Enhancing artisanal food production;
- Developing local food products;
- Distribution and expanding market access;
- Better ability to produce organic foods;
- Non-edible horticulture;
- Non-edible agriculture.

Research relating to food might also be linked to research within the Food for Health theme and Value Chain research subject areas (noted below); as they relate to trends and are consumer-focused.

1. Emerging Opportunities

Research areas included under this heading:

- How to prepare for the "next big thing". The research on this topic is to examine what other jurisdictions do to understand and anticipate what consumer trends will develop or can be developed in the future.
- Benefiting from new technological advancements; here the emphasis is two-fold. One part is to help make product developers aware of scientific break-through in order to alert them to potential applied research. The second is the adaptation of technology in other jurisdictions to Ontario conditions.

2. Food Safety, Traceability and Other Certifications

Research areas included under this heading considered important include:

- Improve and/or streamline food safety systems;
- What are the barriers to the adoption of food safety protocols including harmonization with (international) standards?
- Limiting the extent (and perhaps likelihood) of product recalls from facilitating the sharing of timely and accurate information throughout the value chain.

3. **Packaging**

   Research areas to discover and use new technology to create innovative packaging that will:

   - Reduce cost;
   - Improve performance relating to distribution;
   - Reduce the waste stream effects (i.e. reduce physical packaging, biodegradable packaging);
   - Improve storage and/or shelf life.

4. **Regulatory Modernization Research**

   Areas within this subject considered important include:

   - Understanding the cost of our regulatory system (i.e. lost opportunity cost in food processing);
   - Understanding how reforming legislation and the intent of legislation and related regulations from Health Canada, CFIA and/or Pest Management Regulatory Agency (PMRA) may add value to the Ontario agri-food industry (i.e. labeling interpretation and enforcement);
   - Risk analysis that includes cost benefit analysis, in addition to human health and environment;
   - How marketing legislation should/could be more value chain friendly;
   - Environmental regulations (i.e. nutrient management);
   - Labour regulations (to stimulate greater efficiency within value chains).

5. **Sustainability**

   Research projects under this subject area that were considered important include:

   - Discovering functional attributes of co-products (creating something from a waste product);
   - Reducing waste in food processing, relating to environmental sustainability;
   - Waste stream utilization;
   - Alternative energy, energy management (environmentally friendly);
   - Reacting to economic factors (i.e. rising prices, lessen fuel cost impact of a certain sector);
     - Understanding current environmental footprints/audits/energy used
       - What is the cost of current energy use and the environmental impact?)
     - How can existing capabilities and/or resources be used better or more efficiently?
   - How can we better utilize something we already have – e.g. using our land resource most effectively?

- How to add value with what we have (products/capacity/resources).

B Value Chains, Subject Areas for Research

Parts of the value chain, though not the entire chain, must be based in Ontario, and Ontario may or may not be the market, rather "*the world is the market*".

1. Competitiveness [high priority]

How can Ontario compete against the best in the world?

- Productivity techniques (e.g., lean management);
- What are world leaders doing? (best practice).

2. Relationship/Business Models [high priority]

Research areas defined within this subject that are considered important are:

- Understanding the lifecycle of relationships;
- Identifying characteristics of leaders;
- Improving communications;
- Understanding why some value chains fail;
- Providing scope or understanding of value chain profit/business models to help current or future value chain participants (i.e. adjusting expectations);
- How to improve co-operation between and/or link across ministries (develop cross sectional/inter-ministerial value chains);
- As they relate specifically to rural vs. urban needs (i.e. infrastructure, distribution, scale and geographic specificity);
- Business and relationship models relating to food safety and traceability systems.

3. Communications/Networking [high priority]

- What communication models work? (i.e. best practice models from other jurisdictions to understand links between science and business);
- Information sharing and access between ministries and industry (i.e. developing cross sector/inter-ministerial value chains);

4. Market Intelligence Opportunities [high priority]

- Defining market opportunities (i.e. niche markets, food service);
- Guidance and support for developing capacity in businesses and value chains to identify and utilize business/market intelligence.

5. Human Resources Capacity [medium priority]

- Aligning management skills beyond individual organizations (i.e. a smaller company dealing with a larger company);
- Enhancing value chain management related skills through education and training;

- Food quality management (i.e. quality consistency).

4: Critical Success Factors

4.1 Description of Critical Success Factors

a) Need to access market in a timely way [**high priority**]

   - Research infrastructure needs to be proactive, give industry a concept (if businesses able to accomplish privately in conjunction with researchers, more opportunities will occur to take the concept and develop it further by commercializing findings);

b) Maintaining & guarantee confidentiality [**high priority**];

c) Industry owning intellectual property through commercialization process [**high priority**];

d) Ability for participants in a value chain to participate in the entire research and commercialization process (including flexibility of academic appointments) [**medium priority**];

e) Improved marketing of research and innovation capabilities to industry by OMAFRA, U of G, and associations [**medium priority**];

f) Simplification of the process (ease of access by industry to research) [**medium priority**].

5: Other Related Considerations and Recommendations

5.1 Observations

Canadian universities are industry-focussed when they rely on funding from industry rather than from public funding. By creating a sense of urgency among researchers, through challenging them to work more closely with industry, the current process will see them be more responsive to the needs of the business sector.

What kinds of IP research will assist commercialization? There needs to be flexibility in the ownership and usage of IP. If 'right of first refusal' is not the best policy, what are the merits and constraints of the alternatives?

PRODUCTION SYSTEMS

1: Description and Scope of this Theme

1.1 The Approach

For farmers:

> How can I enhance my farm productivity and profitability? (economic stability, and new challenges/opportunities)
>
> How can I adapt to societal or external pressures and variables? (links to other themes)

For researchers:

> What do we need to do to answer these questions for farmers? ("reverse engineering" i.e. when the market or society provides the direction, Production Systems research engages to provide the solution.)

1.2 Theme Description

First and foremost, Production Systems research must focus on production research and profitable agriculture. Secondly the Production Systems research capacity can be employed to incorporate the needs of other themes into profitable systems.

The Production Systems Theme encompasses the development of agricultural production systems that will enhance profitability of agricultural production, while incorporating issues, opportunities and advances arising from related research areas that address the greater societal milieu within which production agriculture operates, including environmental sustainability, emergency management, end product expectations with regard to food (healthy eating) and non-food (industrial) uses, value chain opportunities and government agriculture and economic development policy directions.

2: Context and Background for this Theme

2.1 Key Assumptions

- There is benefit to OMAFRA funding research throughout the applied to basic continuum, with the more critical question being whether the research could be tied to some potential economic gain. The focus of Production Systems research should be on supporting good science that will have a market at the end (must have an economic end-target.
- Public genetic improvement programs are needed in this theme for some, but not all crops. The strong resource and research base in the private sector is concentrated in genetically modified

traits in 3 major crops, soybeans, corn and canola. There are many examples where Ontario based plant breeding has not only put Ontario in a more competitive position but has also had global impacts from the research. Examples include the Millennium variety of asparagus, in high demand and paying significant royalties to the industry and Yukon Gold potato that is the most widely grown variety in the world. This type of public research is vital to the fruit and vegetable industry in Ontario, where very little private research is done.

- Economics should be the key driver of Production Systems research, supported by the objectives of sector stability and prevention of lost opportunities.
- Opportunities for future markets or product utilization advancements could be undermined if struggling commodities received less research.

2.2 Trends and Opportunities, Issues and Barriers

Agriculture will continue to be a major economic engine in Ontario, with enhanced returns from the bioproducts and food for health fields.

Agricultural input costs will remain high and there will be plenty of impetus to reduce input use.

Food safety and traceability will continue to attract a great deal of attention and will demand research.

There will continue to be new and alien animal and plant disease and pest threats, affecting production, human health and impacting trade opportunities. At the present time, all livestock species have their own challenges, whether it is Porcine Reproductive and Respiratory Syndrome (PRRS), Johne's, BSE, etc., they are all impacted by something.

Climate change will create both opportunities and challenges.

Markets will source agricultural products to address many societal challenges in addition to nutrition. Most of those challenges will involve the utilization of components in familiar crops and livestock, but others will require the introduction of new specialized traits into those products or the adaptation of new crops to Ontario conditions.

The future is not necessarily represented by large, specialized farms. Some foresee an agricultural sector in Ontario with opportunity for smaller and more diverse farm operations and for farms serving niche and innovation markets.

2.3 Dependencies and Linkage with the Theme

Linkages between the research themes are viewed as the most critical factor determining the success of OMAFRA funded research. Few of the challenges facing Ontario agriculture or the opportunities which exist can be addressed under a single theme.

Researchers should develop communication channels across research areas and with the private sector.

Successful research outcomes will be dependent on linkages between research institutions and the members of those institutions as well as between research funding organizations including farm organizations.

Staying abreast of global developments will require researcher contact with experts in trade, global marketing, global economic matters, etc.

It is also important to be connected with research being done elsewhere.

3: Research Areas and Priorities for this Theme

3.1 The Approach

The high priority areas of Productions Systems research are considered the most critical because the issues they address fall within the responsibility of government. Animal and Plant Health and the Impact of Agriculture on the Environment are closely tied to societal priorities, are often related to government regulatory schemes, involve Ontario specific challenges and are supported to a smaller extent by private sector research. On that basis, there is a strong justification for public sector research.

The continued priority of production efficiency relates to the significant economic contribution of agriculture to Ontario's economy, and to the interrelatedness of efficiency research and the three other high priorities. Being positioned to address the needs in the other three high priority fields requires investment in production agriculture research.

Product quality improvement and product diversification were rated as medium priorities because, although very important, they did not have the same degree of alignment with the government mandate, they are areas where the private sector injects more research and influence, and they are somewhat less critical.

Genetic technologies and reproductive technologies competency were added because these technologies act together as a platform for success in the high and medium priority areas.

3.2 Description of Research Areas

High Priority

A Plant Protection

- Invasive alien species (weed, pathogen, and insect management)
- Pesticide resistance
- Controlling spread of pest, pathogens and myco-toxins – for human and animal/crop health
- Diagnostic techniques and disease surveillance methods

B Animal Health and Welfare

- Production limiting diseases (incl. detection methods – e.g., prions)
- Zoonotic diseases (linked to Emergency Management Theme)

- Animal welfare/behaviour
- Antimicrobial resistance and the use of non-antibiotic therapeutics
- Emerging and foreign animal diseases
- Biosecurity and traceability
- Diagnostic techniques and disease surveillance methods

C Production Efficiency

- Profit enhancement and improved efficiencies
- Reductions in labour
- Energy saving technologies and processes
- Reduced input costs
- More efficient use of land, labour, energy, etc.
- Waste stream reduction and reuse
- Alternate livestock feeds

D Environmental/Ecosystem Impact

- Resource use, including water management
- Environmental impacts on natural and man made environments
- Alternate pollinators
- Alternate energy generation
- Climate change induced challenges and opportunities
- Reduction of harmful emissions
- Maintain biodiversity

Medium Priority

E Product Quality Improvement

- The introduction of traits for human health (Omega in eggs or milk)
- The introduction of traits to enhance value – (higher oil content)
- New markets or new products
- Storability and post harvest extension/shelf life

F Product Diversification

- Biomass production and use
- New product development and associated production systems
- Climate change response – different crops, or different production strategies
- Expansion of crop production to different land
- Platform Competency and Capacity

G Genetic Technologies and Reproductive Technologies

- This is a key "how?" rather than "what?" of 1) to 6)
- Developing new products and specialty crops
- Enhancing the marketability of existing products
- Improved productivity – disease resistance or drought tolerance
- Gene pool retention

4: Critical Success Factors

4.1 Factors Over Which We Have Reasonable Control:

- Money: The provision of adequate research funding and the assignment of that money in the most beneficial manner will be critical to achieving success.
- Smarts: The ability to select strategic areas of focus and to select research projects that have demonstrated science quality and relevance to the sector; the ability to target research.
- Infrastructure: Physical research infrastructure and high quality people with a track record of delivering results.
- Others mentioned: networking (including globally) and collaboration/facilitation with other research groups, stable workforce and ability to achieve tech transfer.

5: Other Related Considerations and Recommendations

5.1 Other Recommendations

There is enough concern about the regulatory burden on agriculture to raise it as an outstanding issue, even though it does not form part of the Productions Systems Theme. It is noted here to highlight its importance and to recommend that it form part of the agricultural policy theme.

CONCLUSION

The priorities in this document are intended to help UofG program designers to develop programs that respond to the needs and opportunities identified by OMAFRA. It is essential that UofG program administrators and researchers consider the issues and opportunities addressed in this document when preparing research proposals. OMAFRA staff should be contacted if there is any confusion concerning the research priorities under any theme (Manager: Research Program Coordination 519-826-4173).