



Future Challenges of Education and Research
For a Safe and Secure Food Supply
in Quebec

Memoire

Presented by

Dr. Chandra Madramootoo Ing., FCSBE, FASABE
Dean, Faculty of Agricultural and Environmental Sciences
Macdonald College of McGill University
Ste. Anne-de-Bellevue, Quebec

Commission sur l'avenir de l'agriculture
et de l'agroalimentaire québécois

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FOREWORD

This document is prepared at the invitation of the Commission sur l'avenir de l'agriculture et de l'agroalimentaire québécois, and is to be presented at the Commission's hearings on August 28, 2007. The Quebec agri-food sector is significant to Quebec's economic and social well being. The sector also plays an important role in the stability and prosperity of the regions. There is a concerted attempt by the public and private sectors and the universities in Quebec to ensure the continued vitality of the agri-food sector, and to help the sector attain a position of international promise in terms of new market opportunities and economic competitiveness, especially given the evolving global trading arrangements. The challenges facing the sector are quite significant and far reaching. This paper in no way is meant to deal with or discuss all the complexities and challenges in the agri-food sector. Only some of the key issues and challenges are discussed in relation to the innovative education and research programs being undertaken by McGill's Faculty of Agricultural and Environmental Sciences. These are also discussed in light of the emerging issues confronting the sector, in which the Faculty is gearing up to play a leadership role, in terms of new academic program development, new research programs and the hiring of staff.

Several individuals in the Faculty contributed to the preparation of this report. They include: Helen Fyles, Don Smith, John Henning, Caroline Begg, Peter Enright, Kristine Koski and Valerie Orsat.



INTRODUCTION

Macdonald College, located in Ste. Anne De Bellevue, Quebec, is home to the Faculty of Agricultural and Environmental Sciences of McGill University. The College was founded just over 100 years ago, through the generosity of one of Quebec's greatest benefactors at the time, Sir William Macdonald. It was Sir William's conviction, that the rural well being and the quality of life of the people in rural Quebec, could only be improved through training in the modern techniques of agricultural and household science, and in having rural schools equipped with well trained teachers. For these reasons, Macdonald College originated with a School of Agriculture, a School for Teachers and the School of Household Science, at the time of its creation.

Generations of staff and students who have worked and studied at Macdonald College over the past 100 years have all been inspired by Sir's William's convictions and aspirations. This is evident by the numerous innovations and contributions which they have made over the century to the improvement of Quebec's agri-food sector. We recall with pride, for example, the work of Professors Emile Lods and Raymond in cereal breeding and improved crop varieties; Professor John Moxley, who created the Dairy Herd Analysis Service, which was the forerunner of Valacta; Professors Gerard Millette and Angus MacKenzie who implemented the Land Use Planning and Soil Test Services, and; Professors Pierre Jutras and Robert Broughton who pioneered the modern engineering design and construction of subsurface drainage systems. These Macdonald professors all highlight another important characteristic of the Faculty, in that they demonstrate that teaching, research and service to the community go hand in hand, and that was exactly the vision of Sir William.

Our graduates, some 10,000 since the College's inception, have made and continue to make enormous contributions in such diverse fields as animal and plant genetics, agricultural sciences, nutrition, dietetics, bioproducts and bioprocessing, food engineering, drainage, irrigation, soil and water quality, biotechnology, parasitology, environmental policy, resource economics, environmental protection and management, bioinformatics, soil bioremediation, nutraceuticals, functional foods, climate change, and energy.

Innovation in education has been a hallmark that has characterized Macdonald over the past 100 years. We were the first Faculty of Agriculture in Canada, in the 1930s, to have changed our undergraduate degree designation from BSA to B.Sc (Agr.Sc.), in order to put more fundamental science courses into the curriculum. We went even further in the 1990s to emphasize the unique link between agriculture and the environment by changing the name of the Faculty from Agriculture to Agricultural and Environmental Sciences, and changing our degree designation to B.Sc.(Ag.&Env.Sc.). In addition, the Faculty has been a pioneer in multidisciplinary training and this continues to be a feature of our research and training programs. In fact, Macdonald was one of the three founding Faculties of the McGill School of Environment (MSE), and the MSE is now a major

vehicle for the delivery of trans-disciplinary programs in the environment throughout McGill, and the Faculty is a strong contributor to the MSE teaching programs.

Macdonald College is nationally and internationally renowned for its training of the new generation of leaders, the dissemination of knowledge, and in research and development, and technology transfer in the agri-food, environmental, nutrition and health sectors. McGill University remains strongly committed to the important role which the Faculty of Agricultural and Environmental Sciences can play in the transformation and modernization of the traditional agri-food sector, capitalizing on the latest and most modern advances in the applied biosciences and life sciences.

We live in a rapidly changing world, and it will be important for the Faculty, as an advanced teaching and research institution, to help Quebec position itself as an economically competitive producer of clean, safe and secure food and bioproducts within the global economy. Extending from Quebec, with a global reach in mind, our collective goal is to ensure that humanity's present and future agriculture, food and nutrition needs are met while at the same protecting the environment, conserving natural resources, and safeguarding human health.

The Faculty of Agricultural and Environmental Sciences believes that the production of safe, high quality food in a socially and environmentally sustainable manner is essential to the future of Quebec. The challenge is to work together to provide the agriculture and agri-food sector with the knowledge and tools required to maintain the highest standards of safety and remain viable in today's global marketplace. This will necessitate that the Faculty build on its wide range of expertise and programs in the broad areas of applied biosciences, environmental sciences, food and nutritional sciences, and disease prevention.

BROAD CHALLENGES

There are profound changes sweeping through the agriculture and agri-food industry that will present serious challenges to the agricultural community. At the animal/crop producer level, the age of farm operators is rising; the number of farms continues to drop while farm size increases. In 1991, the average age of farm operators was 44.3 years old compared to 49.3 in 2006. The proportion of farmers in Quebec under 35 years dropped from 13.7% in 1991 to 11.3% in 2006 while the proportion of those over 55 increased from 25.9% to 32.3%. The number of farms declined from 38,076 to 30,675 during the same period. Dairy cattle and milk operations continue to make up the greatest proportion of the farms (26.5%), followed by beef cattle ranching and feedlots (15.7%) and swine operations (6.9%). Animal production systems accounted for 63% (or over \$3.4 billion) of the monetary receipts for agricultural production in Quebec in 2005. Average farm size increased from 90 ha in 1991, to 113 ha in 2006. As the size of the farm family declines, there are fewer skilled people available to work at peak times on the farm. In addition, fuel, fertilizer and labour costs are rising, and although grain prices have increased



recently, total net farm income in Quebec has declined over the last five years from an average of \$460 million to \$430 million.

At a broader level, issues around environmental degradation, water quality, and food quality and safety have increased societal and consumer concerns, and resulted in an increasingly regulated industry that places additional requirements on producers. For example, a recent survey of businesses that deal with the Canada Food Inspection Agency (CFIA) reports that agricultural producers spend about 19 days a year and \$19,000 just to comply with CFIA regulations.

The greatest challenges facing Quebec agricultural producers and food processors however, lie beyond the immediate control and reach of the farm operators. These challenges include:

- Changes in the value of the Canadian dollar and interest rates;
- Climatic change, and its potential impact on water availability and quality, not just in Quebec but in other agricultural regions of the world;
- Globalization of the market place accelerated by improved methods of food preservation, faster transportation and the internet;
- Increasingly wealthy populations in India and China where up to 40 million people enter the middle class each year bringing with them higher demands for meat products;
- increased energy costs
- Global trade negotiations and the goal of wanting to reduce all forms of export subsidies within the next 10 years

All these factors will have profound effects on what and how we produce, process and market our agricultural commodities and food products.

On a broader scale, the Canadian federal and provincial governments are looking for ways to work together to ensure a competitive and profitable agriculture and agri-food sector that provides safe and high quality products. In the United States, the USDA report “Food and Agriculture Policy: Taking Stock for the Next Century (2001) examines trade, farm sector policy, food system infrastructure, and environmental and nutritional issues to “confront and manage the change immediately before us while at the same time modernizing our farm and food system infrastructure to ensure continued growth and development for the 21st century”. The European Union created a Standing Committee on Agricultural Research that met in June 2007 to discuss the results of a foresight process that identified four futures scenarios: climate shock, energy crisis, food crisis, and cooperation with nature.

RESPONDING TO THE CHALLENGES

The challenges outlined above are numerous and may seem daunting. It is impossible for any one institution to tackle all these challenges. However, it is important that the people of Quebec empower their universities to tackle these problems. We will need to harness the significant talent and resources in all the universities to be able to do the research and



find solutions to the above challenges. We need to continue to foster the linkages between the various government ministries, the universities and the private sector, so that appropriate policies, practices, technologies, and products are brought forward to enhance the economic competitiveness of the agri-food sector, while paying attention to the environment, and human health and well being.

McGill's Faculty of Agricultural and Environmental Sciences, rooted in the vision of Sir William Macdonald, is committed to playing its role, in conjunction with all its institutional partners, in helping Quebec's agri-food sector to address the challenges of the future. The research and teaching carried out at Macdonald College cover a wide range of agricultural and agri-food issues related to animal and crop production, the environment and food and nutritional sciences. The intellectual strength of the Faculty is demonstrated by the attached listing of our tenure track staff and their areas of expertise. As we recruit new staff, develop new academic and research programs, and build up our infrastructure, we are making a conscious decision to help Quebec meet the demands being placed on conservation and protection of the environment and natural resources, a safe and healthy food supply system, development of new marketing opportunities, and provision of highly trained personnel. These aspects are described in more detail below.

1. Resource Conservation

The general trend towards more intensive agriculture, especially in the St. Lawrence basin, has had a significant impact on the environment, including quality and quantity of surface water and groundwater, soil erosion, and loss of biodiversity and habitats. Increased inputs of fertilizer and manure onto agricultural fields without sufficient knowledge about effects of nitrogen (N) and phosphorous (P) loading on local and regional water systems have been part of the cause of significant algal and cyanobacteria growth in the rivers and lakes of Quebec. Such problems raised the awareness of agricultural producers, the public, and the government to the need for better water quality controls particularly for phosphorus. Regulations now limit nutrient applications to fields. Environmental farm assessments and action plans to mitigate environmental damage were carried out on over 8000 farms by Spring 2005. Nevertheless, there is much more to be done in education and research in the area of animal waste management and disposal systems, in order to reduce soil and water pollution. The interaction of the intensification of agriculture, technological innovations, and climate change will put increasing pressure on our soil and water resources. The development and implementation of best management practices to reduce this impact, particularly with regard to water quality is of utmost priority.

Loss of top soil and organic matter from excessive tillage and inadequate crop cover, particularly during the spring severely reduce soil fertility and consequently crop yields. Intensive continuous cropping is also a contributing factor. More attention to improved tillage practices, soil management systems, cover cropping, and crop rotations is required. Pursuing a more aggressive path towards advanced technologies such as



precision agriculture will further help to manage soils and crops in a more sustainable manner.

Heavy rains in spring or summer and seasonal droughts during the growing season demand both soil drainage and irrigation, if crop yields are to be maintained. Research into drainage of the most problematic soils (layered soils, fine sandy or silty soils) is required. Efficient and effective use of irrigation, essential for high value crops, requires ready access to weather data, plant and soil indicators for irrigation scheduling and information identifying costs and benefits of different irrigation techniques for various crops, none which is currently available to Quebec producers.

Biological diversity is of fundamental importance in supporting agricultural production and sustainability. Genetic diversity provides access to seeds and plants better adapted to future climatic conditions (e.g. drought-resistant traits or resistance to pests and disease), and is the basis of adaptation as needs and environmental conditions change. Agricultural production is based on utilizing biological diversity. About 7000 plant species have been cultivated and collected for food by humans over the last 12,000 years. Today however, only about 15 plant species and 8 animal species provide 90% of the global demand for food. Genetic preservation of plant and animal species is therefore of extreme importance. It is estimated that the risk of biodiversity loss is high when forest cover falls below 30% in a given area. In the St. Lawrence Valley, more than 70% of the forest habitats have disappeared and habitats of native species have been changed or eliminated. Wooded areas on farms can provide cover for native animal and plant species, improve water quality and reduce soil erosion, and have therefore become increasingly important for maintaining or possibly increasing biodiversity. There is a need to preserve these forested areas.

Integrated watershed management and sustainable animal and crop agriculture are pivotal to resource conservation. Continuing to teach these concepts and to undertake the research needed to achieve these under the wide range of Quebec's climate, soils, and environment will be critical in the future.

2. Safe and Healthy Food

A better-educated and health conscious consumer is driving many of the changes in food production and the processing industries. A growing interest in a healthy lifestyle and diet coupled, with the problems of animal diseases and scares related to the presence of banned substances in foodstuffs as well as concerns about environmental issues such as water quality, and water and food borne diseases have resulted in a strong demand for high quality, safe food products.

The food industry, which originally provided only primary products for final preparation in the home, finds itself responding to market demands for more refined, sophisticated, and convenient products. In 2005, a staggering 16,000 new food products were introduced in the United States alone. The demand for easy to prepare, convenience

foods, due to a busy lifestyle poses major scientific and technological challenges which cannot be met without highly trained scientists capable of understanding the complex chemistry/biochemistry of food products and knowledge of the preservation and processing methods. This increased reliance on ready-to-eat foods has led to greater responsibility for processors in terms of quality, safety and nutrition. In order to ensure high quality and market competitive products, scientific principles and new technologies are being applied to food manufacturing and the body of knowledge required has become the discipline of food science.

Immigration also impacts on food consumption and dietary patterns. Newcomers to Quebec have a desire for their traditional food products, and we consequently see new products on supermarket shelves. This will impact the food and nutritional needs of a changing Quebec society, and consequently force us to produce a much wider range of crops, as well as enter into the processing of these crops to produce non-traditional food products. One significant advantage of this evolution is that it could open new international markets for Quebec agri-food companies.

Technological change is now a watchword in the food safety area. For example, in the fresh vegetable trade, there is a trend towards more field mechanization and reduced human labour. More people handling fresh vegetables may lead to contamination of the food product. Therefore less human handling and a higher degree of mechanization from harvesting to packaging, will minimize human contact, and consequently potential food disease outbreaks.

Providing consumers with safe food is also linked to different life styles, food habits and food choices. Poor nutrition is connected to disease and obesity resulting in rising health care costs. In 2004, 22% of Quebec's population was obese and an additional 35% was overweight due to poor diet and an inactive lifestyle. The direct health costs associated with obesity were estimated at \$2.1 billion in 2001 and indirect costs at \$2.7 billion. The health and well-being of individuals in relation to food choices and physiological status prevails as the unifying theme of the programs in Macdonald's School of Dietetics and Human Nutrition. The availability of food, normal metabolism and clinical nutrition, community nutrition at the local and international levels, the evaluation of nutritional products and their use in nutrition, and the communication of information about food and health form the core of the School's academic programs.

3. New Market Development

New opportunities and alternative products lead to additional markets and improved economic viability for agricultural producers. Nutraceuticals, organically-certified products and bioproducts and biofuels are examples of products that add value to traditional commodities.

Consumers are increasingly interested in the health benefits of foods and have begun to look beyond the basic nutritional benefits of food, to disease prevention and health



enhancing compounds contained in many foods. Combined with a more widespread understanding of how diet affects disease, health-care costs and an aging population, this has created a market for functional foods and nutraceuticals. According to market statistics reported by Agriculture and Agri-food Canada (AAFC), the global functional food and nutraceutical market is growing at a rate that is outpacing the traditional processed food market. The Faculty of Agricultural and Environmental Sciences is currently carrying out research to identify beneficial compounds and secondary metabolites and approaches to enhancing their content and bioavailability in commercial foods. Research to exploit health related properties of natural products from plant sources will target specialty compounds like antioxidants, and plant extracts for the treatment of diabetes, depression, Alzheimer's disease etc. The chemical prospecting of plants offer enormous potential for human health promotion in the production of pharmaceuticals, natural health products or functional foods.

The desire for healthy, safe, food products, coupled with a rising awareness of the ecological footprint of imported food, has spawned an increased interest in locally produced products which are often grown organically. Rates of retail growth of organic products are increasing at 20% per year and there is rising interest in community supported agriculture. At the farm level in Quebec, this change in consumer demand is increasingly being met by a new kind of producer: someone who is young (under 35 years), has a 50% chance of being female, likes to work cooperatively and grew up in an urban area. A number of these young people have passed through Macdonald College in recent years. These are people who are well-educated and driven by the ideal of providing healthy food in an environmentally sustainable way. They are not currently eligible for any of the government supported programs that encourage young farmers to remain in agriculture, although their contribution to growth in the organic food industry is essential, and they could be catalysts for significant improvements to environmental practices. Quebec has a legally accredited organic farm certification system that is unique in Canada and we should capitalize on this strength.

Sharp increases in fuel costs have generated a great deal of interest in biofuels as a way to reduce farm energy inputs and to generate more wealth in rural communities. AAFC has recently introduced the Agricultural Bioproducts Innovation Program to build greater research capacity in agricultural bioproducts and bioprocesses. Researchers at Macdonald are pursuing initiatives on biodiesel production from canola, soybean, C4 grasses, shrubs and trees. There are huge knowledge gaps in this area of research such as: how to increase plant biomass at an accelerated rate, what genetic improvements can be made to increase oil production, and what are potential byproducts of a biorefinery (such as cosmetics, inks, plastics) that can make the production system more profitable. There is significant potential for biofuels to become an important part of the Quebec agricultural sector. The McGill Network for Innovation and Bioproducts was recently established at Macdonald College to link researchers within McGill and between other universities or research institutes to make research more collaborative and effective. This network will also disseminate innovations generated by the biofuel research to the Quebec agricultural community.



The impact of biofuels on the purchasing power of Quebecers is not yet fully known. Will the use of corn and alternate crops to produce fuel cause a rise in food prices? Will these practices require higher inputs and improved soil and water conservation? Much is un-known about these other factors, and point to the need for more science and policy research on the topic.

4. Highly qualified human resources

The most important tool to meet future challenges of the agriculture and agri-food sector in Quebec will be well-educated, highly trained personnel who are capable of making the rapid adjustments necessary to keep the agriculture and agri-food industry viable. An ongoing review of the academic programs of Macdonald College has identified the need for changes to undergraduate program and course content in order to meet the evolving needs of the industry. Entrepreneurship, experience in making business plans, costing new products for market, and cost-benefit analyses of new technologies are essential for today's producers. Environmental sustainability needs to be a horizontal theme that runs through all programs so that soil and water resource management at farm and community levels, environmental impact assessment of current and new methodologies, climate change here and throughout the world, and environmental regulations and the theory behind them, all become basic knowledge of the graduate.

At the same time, there is concern in the workplace that conventional areas of agricultural study are being forgotten even though there is a need in the workforce for students with a broad agricultural background. Interpreting information and making the best use of technological innovations requires a thorough understanding of basic processes whether they are animal, crop or soil related. Students who do not come from agricultural backgrounds but who want to work with producers or start farming, such as the organic producers described in section 3 above, should be provided with essential practical skills. Courses and programs need to be updated and repackaged to attract students to the wide variety of careers now available in agriculture and agri-food science.

Life sciences are at the heart of today's developments in animal and plant agriculture, and even in the environmental sciences. Students will need to have basic and fundamental knowledge of biotechnology, bioinformatics, genetics etc. in order to understand modern animal and crop biosystems.

Research carried out at universities also provides valuable training for graduate students who wish to become experts in their field of study. Such researchers are on the cutting edge of scientific advancements and play an essential role not only in technological innovation and environmental mitigation, but also in educating policy makers to allow them to make informed decisions.

To meet the demands of a rapidly changing work place and the innovations in agriculture and the agri-food systems, McGill's Faculty of Agricultural and Environmental Sciences

is recruiting highly qualified scientists from many different disciplines. New hiring has targeted towards developments and researchers in fields such as epigenetics, nutrigenomics, molecular parasitology, bioprocess engineering, bioinformatics, nutraceuticals, molecular biology, genomics and proteomics, ecological genetics, and biopesticides. We believe that this ever evolving and modernized academic staff will bring the new technologies and research ideas into the undergraduate and graduate training programs.

A further strength of Macdonald College is its delivery of the pre-baccalaureate Farm Management and Technology (FMT) program. This DEC level program is intended to train students who will enter the farming or agri-business work force. The FMT program has evolved remarkably with time, and is constantly seeking ways to ensure that the student body is being trained in the latest technologies and practices. An advantage of the McGill FMT program is that the students are able to draw on the expertise of the regular Faculty teaching staff, and the field and lab resources of Macdonald College.

As pointed out earlier in this document in the section on *Broad Challenges*, Quebec's farm demographics have changed dramatically in the recent past. We have fewer and aging farm families. Educational programs will need to take these demographics into account, and new ways of transmitting latest technological advances to farms and agribusiness require development. Equipping young people who have no previous knowledge in agriculture is perhaps an area requiring a concentrated effort by the government, universities and the ITAs. Targeted teaching programs geared to certified organic production, production of high-value speciality crops, food safety, food processing, food ingredients and additives, functional foods, nutraceuticals, and bioproducts and bioprocessing will have to be developed both for meeting consumer demands and preferences, and also to open up new marketing opportunities internationally. These courses can be delivered through both the FMT and regular undergraduate programs.

CONCLUSIONS

In the changing environment of today's agricultural and agri-food industries, knowledge-based agricultural systems are required that are profitable at the farm level, are environmentally and socially sustainable, produce internationally competitive food products, can cope with climate change, and are energy efficient. It is a demanding objective and one that requires an effective coordination of information and technology transfer between industry, government policy makers, educators and researchers, not just within Quebec but across Canada and throughout the world..

McGill's Faculty of Agricultural and Environmental Sciences believes that Quebec's agriculture and agri-food industry is on the path to being positioned as an internationally recognized source of high quality, safe food products grown in an environmentally sustainable manner. This positive image of our locally produced food will resonate with



domestic and foreign consumers alike who are increasingly wary of food supplies that do not meet international and national regulatory standards, and lack the nutritive essentials for proper health and diet. Quebecers are also highly conscious of environmental quality and wish to see a safe and secure food production, processing and supply system tied to stringent environmental safeguards. Adding value to basic agricultural commodities and searching out the niche market opportunities remain of utmost priority.

Universities, the government and the private sector must work hand in hand to achieve these goals. McGill University remains committed to playing a leadership role in the training of undergraduate and graduate students in all areas of animal and crop agriculture, applied biosciences, food and nutritional sciences, and environmental sciences. The Faculty is modernizing its undergraduate curriculum, and hiring new staff to provide the leadership required, given the rapid evolution in the various fields. Our staff are further committed to undertaking the research which will help Quebec be an economically competitive world leader in the safe production, processing and distribution of food products, which also lead to improved human well being. In addition, the College reinforces the importance of its pre-baccalaureate Farm Management and Technology (FMT) program, which is critical to training the next generation of leaders who will operate at the farm level, or be active in agribusiness. We will also build on our increasing emphasis and unique strengths in interdisciplinarity, in the assembly and delivery of our research and teaching programs.

We recognize the changing farm demographics in Quebec, but firmly believe that this opens up new possibilities and opportunities for different forms of training and research in fields such as: production of high-value speciality crops, food safety and toxicology, food ingredients and additives, functional foods, nutraceuticals, animal biotechnology, crop and animal disease diagnostics, parasitic diseases, sustainable agriculture, soil and water quality management, protection of biodiversity, bioproducts and bioprocessing, and nutrition and disease prevention. The Faculty will actively incorporate the latest developments in the biosciences and life sciences as the basis for enhanced education and research in these fields.