

**ONTARIO SOIL, WATER AND AIR
RESEARCH AND SERVICES COMMITTEE**

2002 ANNUAL REPORT

TO

**ONTARIO AGRICULTURAL SERVICES
COORDINATING COMMITTEE**

JANUARY, 2003

ONTARIO SOIL, WATER AND AIR RESEARCH AND SERVICES COMMITTEE

2002 ANNUAL REPORT

Prepared by

Ivan O'Halloran, Chair, OSWARSC
Keith Reid, Past-Chair, OSWARSC

with assistance from
Paul Brine, OMAF Research Analyst

Table of Contents

<u>EXECUTIVE SUMMARY</u>	4
<u>INTRODUCTION</u>	5
<u>OSWARSC TERMS OF REFERENCE</u>	6
<u>OSWARSC INDUSTRY/SECTOR SCAN</u>	7
1. <u>MAJOR ACCOMPLISHMENTS IN THE PAST YEAR</u>	7
2. <u>STATE OF THE INDUSTRY</u>	7
3. <u>EMERGING ISSUES</u>	8
<u>BACKGROUND INFORMATION FOR THE 2003 PRIORITY ISSUES</u>	11
1. <u>MANURE MANAGEMENT</u>	11
2. <u>NUTRIENT USE EFFICIENCY</u>	12
3. <u>WATER MANAGEMENT</u>	12
4. <u>SOIL AND CROP MANAGEMENT</u>	13
5. <u>IDENTIFICATION / VALIDATION OF BEST MANAGEMENT PRACTICES</u>	15
6. <u>BIOSOLID / WASTE APPLICATION AND TREATMENT</u>	15
7. <u>RURAL AIR QUALITY</u>	16
8. <u>GREENHOUSE GAS EMISSIONS / CLIMATE CHANGE</u>	16
<u>STRATEGIC RESEARCH RECOMMENDATIONS</u>	18
1. <u>HIGH PRIORITY STRATEGIC RESEARCH RECOMMENDATIONS</u>	18
2. <u>MEDIUM PRIORITY STRATEGIC RESEARCH RECOMMENDATIONS</u>	33
3. <u>LOW PRIORITY STRATEGIC RESEARCH RECOMMENDATIONS</u>	39
<u>RECOMMENDATIONS FORWARDED TO OTHER COMMITTEES</u>	47
<u>APPENDIX</u>	49

Executive Summary

The 2002 Ontario Soil, Water and Air research and Services Committee (OSWARSC) Report represents the first year in the four-year reporting cycle to OASCC, and as such outlines the strategic research directions and recommendations for the up-coming four-year period. Priority issues identified in previous reports still reflect the pertinent areas of research needs, as well as the concerns of the public and agricultural sectors with respect to the production of safe food in an environmentally sound and sustainable manner. As a result, for the new cycle, Research Recommendations have been identified according to the following Priority Issues:

1. Manure Management
2. Nutrient Use Efficiency
3. Water Management
4. Soil and Crop Management
5. Identification / Validation of Best Management Practices
6. Biosolid / Waste Application and Treatment
7. Rural Air Quality
8. Greenhouse Gas Emissions/Climate Change

“Healthy Soils, Clean Air and Safe Water”

In light of recent events in Ontario, it is not surprising to see that the public perspective of agriculture is primarily focused on issues surrounding water quality, particularly with respect to manure and nutrient management. Ontario agricultural producers are starting to see the legislative consequences of the Walkerton Inquiry with the passing of the Nutrient Management Act, Bill 81 by the provincial government on June 27, 2002. The expertise of many of the members of the OSWARSC and its subcommittees has been sought in the development of the guidelines and specific regulations associated with this Act. The Ontario Soil Management Research and Services Committee (OSMRSC) recently reviewed its mandate and responsibilities in preparation of the implementation of the Nutrient Management Act. Research issues surrounding the Walkerton incident and Nutrient Management Act cut across all of the Priority Issues identified above, with the possible exception of Greenhouse Gas Emissions. With ratification of the Kyoto Protocol by the federal government, research issues pertaining to Ontario agriculture's role in meeting Canada's commitment will also gain in importance in the near future. Again, this issue cuts across several of the other Priority Issues as one examines the impact of soil, cropping, manure and nutrient management practices on greenhouse gas emissions. As we move into a new four-year cycle, it is appropriate to reaffirm that OSWARSC is committed to identifying required research that meets the present and future needs of the agricultural industry in Ontario and to demonstrate to the public that through the development and implementation of best management practices we can have an agricultural system that provides healthy soils, clean air and safe water.

Introduction

The Ontario Soil, Water and Air research and Services Committee (OSWARSC) currently consists of three major subcommittees (Ontario Agrometeorology Research and Services Committee (OARSC), Ontario Soil Management Research and Services Committee (OSMRSC) and the Ontario Water Management Research and Services Committee (OWMRSC)). OSMRSC is comprised of six sub-committees pertaining to soil management issues as related to field crops, horticultural crops, soil and water quality, soil test laboratories, tobacco and waste utilization. Memberships and mandates for all of the sub-committee and main committees continue to be reviewed, especially in light of recent changes in how agriculture is practiced and regulated in Ontario.

OSWARSC serves Ontario agriculture by prioritizing research and service needs in the broad areas of:

- , The agricultural and rural community
- , Soil and water management recommendations for agricultural producers
- , Recommendations for agricultural producers that deal with weather and atmospheric conditions

OSWARC continues to organize research recommendations around eight Priority Issues, many of which were identified several years ago. The appropriateness and timeliness of these identified Priority Issues is quickly realized when one considers the recent events such as the Walkerton tragedy and subsequent Inquiry, the passing of the Nutrient Management Act, and ratification of the Kyoto Agreement. In addition, issues concerning water supply and water taking rights (agricultural and non-agricultural) are becoming increasingly important in light of consecutive growing seasons of hot, dry weather across large areas of the province.

Many of the specific strategic research recommendations cut across several of the Priority Issues. This re-enforces the need and importance of developing multi-disciplinary projects rather than smaller individual projects to address the larger issues and the need for increased support of longer-term research projects that can properly address these issues.

OSWARSC Terms of Reference

The Ontario Soil, Water and Air Research and Services Committee (OSWARSC) was formed in 1971 and consists of three subcommittees, namely the Ontario Agrometeorology Research and Services Committee, the Ontario Soil Management Research and Services Committee and the Ontario Water Management Research and Services Committee.

Duties and Terms of Reference

1. To identify soil, water and air research required in relation to present and future needs and opportunities for development of the agricultural industry in Ontario.
2. To assess and make recommendations on the priorities to be applied to these matters.
3. To facilitate means of meeting such needs efficiently with the resource available from time to time by:
 - a. Considering and approving chairmen and membership of subcommittees;
 - b. Evaluating cost-benefits of research;
 - c. Examining the suitability of institutions or persons to assume responsibility for various research programs;
 - d. Projecting resources needed for research;
 - e. Describing how resources may be obtained or freed for new program requirements;
 - f. Reviewing operations of subcommittees through reports submitted;
 - g. Reporting to OASCC on such matters as required; and
 - h. Promoting greater interaction between scientists in soil management, water management, agrometeorology, and soil survey and land use, and between scientists and extension personnel.

OSWARSC Industry/Sector Scan

1. Major accomplishments in the past year

Although research in the past had focused primarily on the agronomic aspects of nutrient management, the trend in recent years has been towards a greater emphasis on management of nutrients that attempt to mitigate the environmental consequences of nutrient application. The passing of the Nutrient Management Act, Bill 81, and the subsequent development of regulations have relied heavily on Ontario based research related to the Priority Issue areas identified in the past by OSWARSC. However, research is ongoing and still needed under many of these priority areas to ensure that nutrient management plans and best management practices achieve the level of acceptable environmental risk without becoming unreasonably prohibitive from the viewpoint of agricultural production.

A listing of the research projects and various subcommittee activities can be found in the individual subcommittee reports to OSWARSC that are presented in the appendix.

2. State of the Industry

Not surprisingly, the release of Commissioner Dennis O'Connor's report of the Walkerton Inquiry on January 18, 2002 has kept water quality as a fairly high profile issue in the public eye. Subsequent passing of the Nutrient Management Act by the provincial government re-enforced the governments pledge to ensure clean safe water in the province. While many in the agricultural community applaud the concept of Nutrient Management Planning, their remains a reasonable amount of anxiety regarding the specific details in the regulations and the potential impact on farm operations and profitability.

Similar to 2001, the 2002 growing season was again characterized by high temperatures and low precipitation, resulting in considerable variability in crop yields throughout the province. Coupled with the cool, wet conditions of 2000, some areas have had three consecutive poor growing seasons. For several horticultural crops, such as cauliflower, the high temperatures in 2002 also had adverse impacts on the quality of the fresh market crops, and promoted the incidence of diseases in the fall for processing crops. The low levels of precipitation has resulted once again in reduced stream flow, and is of concern to many growers who rely upon local waterways as a source of irrigation water for crops. Issues surrounding water taking for agricultural and non-agricultural usage are also becoming more prominent.

As indicate in the following table, fertilizer sales rebounded slightly in 2001 compared to the low experienced in 2000. Previous reports have highlighted the general trend of decreased sales, especially in N, P and K fertilizer since the mid 1980's. One might anticipate a further reduction in overall fertilizer sales with the implementation of Nutrient Management Plans. It is anticipated that the Act will bring about an increase in

the numbers of soil samples analyzed by the accredited laboratories in Ontario, again as part of the requirements for Nutrient Management Plans.

Table 1. Fertilizer sold and Nutrient Content (Ontario)*				
Year End June 30	Total Fertilizer Sold	Nitrogen	Phosphorus	Potassium
2001	754,132	164,617	75,943	112,236
2000	699,986	158,500	64,343	113,427
1999	744,470	168,684	67,200	126,489
1998	782,639	171,971	75,154	134,894
1997	691,232	152,211	70,560	116,571
* data courtesy of OABA				

3. Emerging Issues

Many producers today have expressed concerns regarding the future of the current agricultural industry in Ontario as they deal with the dilemma of decreasing profit margins and increased public scrutiny regarding the impact of farming practices on the environment. Media coverage of events surrounding water and air quality problems linked to agriculture has increased the belief of many people that while high input agriculture has favorably affected agricultural production; this has been done at the expense of environmental quality. While some would suggest that abandoning high input agriculture would solve many of environmental problems associated with agriculture, the real world is unfortunately not that simple. Understanding the effects of management on transport pathways of pesticides, nutrients and pathogens, as well as impact on nutrient cycling is critical in assessing agriculture's impact on water quality and the appropriate actions to take to ensure the safety of our water. Production systems that promote and maintain soil health benefit agricultural production, as well as society as a whole through improvements in both water and air quality. Research that aims at developing sound, economically profitable, and socially acceptable farming systems and technologies must be initiated and supported.

A major limitation identified by in the development of nutrient management plan regulations was the lack of Ontario based data pertaining to nutrient requirements and nutrient removal for many of the horticultural crops grown in Ontario. This issue had been identified for several years as a research need by OSWARSC, but had never been aggressively pursued due to the relatively small acreage of these crops and the limited availability of funding. It is anticipated that there will be greater funding available from both government and producer groups for this type of research in relation to the development of nutrient management plans for these crops.

Research has demonstrated that with rising temperatures, crop yields tend to decline and display greater variability. While the current trend of global warming is not conclusive proof of greenhouse warming vs. natural variation, it does suggest that if this trend continues we can expect lower more variable yields that will in turn impact on

supply, quality and pricing. Management systems, cultivars etc., must be developed and selected not only to tolerate seasonal variability in weather (i.e. higher temperatures and greater risk of drought), but also to produce adequate yield and quality (visual and nutritional). The risk of high temperatures will also place more demand for irrigation water and improved methods of irrigation scheduling.

4. Summary of Soil, Water and Air Issues

This section attempts to provide an overview of the major issues identified by the three subcommittees. These are divided out into issues and research priorities later in the report, but a more comprehensive view may help to place these issues and priorities into context.

Soil: The Ontario Soil Management Research and Services Committee (OSMRSC) is concerned with the impacts of soil management on both crop production and environmental quality. As such, it is concerned with the chemical, physical, biological, and to some extent, economic aspects of soil management.

Manure management continues to be a dominant issue in soil management, especially in view of the Nutrient Management Act. Development of the regulations from an environmental standpoint clearly shows that while beneficial agronomic practices have been identified in past research, question remain as to the impacts on the environment. The concentration of the livestock industry, and increased public awareness of off site impacts, have highlighted the need for understanding how to manage manure, and other organic materials, to maximize beneficial effects while minimizing adverse environmental impact, for a wide range of materials and cropping systems.

Also very important is the understanding of the inter-relationship between crop production systems and soil properties and sustainability. This includes crop rotations, tillage systems and nutrient applications. The development of regulations surrounding the Nutrient Management Act has re-enforced the need to increase the work in this area, particularly as it applies to horticultural crops. These crops have been largely ignored in the past because of the small acreage and wide diversity of crops, but they have the potential for significant environmental impact because of the intensity of the production systems.

Other key areas include identification of sources and pathways of environmental contaminants, and optimization of water management. These issues cross over between soil management, and both water and air management.

Water: The Ontario Water Management Research and Services Committee is concerned with both the quantity and quality of water in Ontario, as it relates to agriculture and rural activities in Ontario. The issues and priorities surrounding this can be summarized in three points:

1. Identify the impacts of changing management practices on the leaching losses of pathogens, nutrients, feed additives (both quantities and timing during the year). To accomplish this, the pathways of contaminant movement need to be quantified, best management practices need to be tested and impacts quantified, and benchmark standards need to be developed for concentrations of contaminants in leaching waters and tile drains.
2. Fair and sustainable water sharing policies need to be developed, to ensure the continued availability of clean water for both agricultural and non-agricultural uses. This may include protection strategies for wellheads and groundwater recharge zones, and innovative irrigation strategies for water conservation and to minimize leaching losses.
3. Both new and old designs for surface and groundwater protection (filter strips, wetlands, tile drain treatment systems, etc.) need to be tested for effectiveness as well as the relative cost and benefit of each system.

Air: The Ontario Agrometeorology Research and Services Committee has focused most of its attention to the effect of weather on crop conditions, particularly with respect to weather based predictive models for irrigation scheduling and pest or disease management. Other identified areas of investigation include: the monitoring and characterization of gas fluxes (especially greenhouse gases) from agricultural lands and potential impact of management practices on these fluxes; assessment of risk of extreme events as related to irrigation requirements and manure management (storage); odours from farms including the methods to identify minimum separation distances and manure treatments to reduce odours; and finally other issues surrounding rural air quality as related to the impact of air pollution on crop production.

Increasing in importance is the issue of climate change that involves two components: measuring and adapting to climate change, and quantifying the net release of greenhouse gases from agricultural activities. Although there is evidence of a trend for global warming, the consequence of this phenomenon on climate change within a given area is still very speculative. However, weather records would suggest that the variability in climate currently being experienced is possibly more the norm, than the relatively stable climatic conditions experienced through the period of time from 1950-1980. Increasing within season and between season variability in weather and climatic conditions will undoubtedly result in greater yield variability, and may adversely affect the quality of certain crops. Management systems and cultivars need to be developed to cope with the potential changes in climatic conditions. Ratification of the Kyoto Agreement will also increase the importance of understanding the role of Ontario agriculture in identifying potential sources and sinks of greenhouse gases.

Background Information for the 2003 Priority Issues

As mentioned previously, the research recommendations have been organized around eight Priority Research Issues identified by OSWARSC as areas confronting Ontario Agriculture. The eight Priority Issues are listed below with a brief outline of the background material associated with each issue. Although not specifically list in order of priority, the Committee felt that the first three Priority Issues were of approximately equal importance, and somewhat of a higher priority than the later ones.

1. Manure Management

Research investigating manure management methods for reducing nutrient and contaminant transport off-site, while improving nutrient use efficiency and crop production.

Much of the earlier research conducted on manure management was primarily focused on the agronomic benefits of utilizing this on-farm resource from both a crop and soil perspective. Today, controversy surrounds the management of livestock manure on many Ontario farms. Increasing public concerns regarding environmental protection are requiring farmers to be increasingly careful of how manures are handled in order to eliminate, or at least minimize, leakages of plant nutrients and pathogenic microorganisms from the farming system. Implementation of best management practices for improving manure nutrient utilization on the farm will require an understanding of the intricate relationships between crop management factors, soil and weather conditions, and manure characteristics.

The method of manure storage, various manure treatment options and application techniques can significantly alter the availability and concentration of nutrient within the manure, as well as the survivability of pathogens. Research is required to identify those storage/treatment /application systems that offer significant improvements in reducing the risk of contamination of air and water resources by manures, while still being a practical farming operation. Manure storage, treatment and application as it impacts greenhouse gas production are other areas of potential importance in the near future (see Priority Issue 8).

Water quality concerns of pathogen contamination required not only a knowledge of how management influences transport, but also factors that influence survivability of the pathogen, whether during storage or after application to the soil. Research must not only identify how management (storage, treatment and application) affects the pathways of potential movement of contaminants, but also assess the timeframe in which this may occur. Managed properly, livestock manures can supply an important part of the farmer's crop nutrient needs without damaging the environment. Farm decision-makers must therefore balance the technical aspect of using these materials as a source of plant nutrients with the environmental aspect of avoiding damage. Moreover, manure management must be thought of as only one aspect of overall farm management.

Handling operations must be combined with livestock and crop production and marketing plans, rather than being treated as separate entities.

2. Nutrient Use Efficiency

Research assessing the effects of management practices on nutrient-use efficiency.

Concern over the impact of agricultural activity on the environment has increased in recent years. In the past decade, it has been repeatedly demonstrated that agriculture is a significant source of ground and surface water pollution. The problems associated with environmental contamination have led to policy and legislation that aims at effectively managing the land application of nutrients in an environmentally responsible manner. In general, the overall aim of a fertility program for crop production is to synchronize the availability of nutrients to uptake requirements of growing crops to reduce the risk of environmental contamination. However, a number of gaps in the existing knowledge are present. Nutrient requirements and application recommendations have been based on yield response with little emphasis paid to the environmental consequences or crop quality. In some cases, particularly in the horticultural industry, a database for calibration of fertilizer requirements to soil test values for both yield and quality is lacking. Field variability, cropping practices and differences in nutrient requirements of various crops, placement and time of requirement impact the overall nutrient management scheme. As a result of this concern, there is an urgent need to establish best management practices that involve establishing accurate nutrient requirements, proper application rates, timing, and methods of nutrient application that maintain the viability of the agricultural sector while minimizing the environmental impact.

3. Water Management

Research directed towards the source protection of water quality and quantity.

Issues surrounding water management can be categorized into two broad areas of water quality and quantity. Quality issues relate primarily to the potential contamination of surface and ground water sources through the off-farm losses of agricultural inputs (fertilizers, manures, biosolids, pathogens, pesticides etc.). Most of these issues are addressed at the process or field level in the other Priority Issues. Effective management of water quality will also require the assessment of this resource at a larger scale such as the watershed or aquifer level. Identification of problems and sensitive areas to contamination will rely on the development of methods that assess all sources (agricultural and non-agricultural) and relative sizes of contamination, the pathways of contamination, potential risks of further contamination, and the capacity of the watershed/aquifer to effectively cope with the contamination.

The importance of the protection of water quantity is most relevant given the recent dry weather and increased use of supplemental water to produce crops. Due to water shortages, provincial ministries are enforcing water use permits and growers are under

the watchful eye of the public as they irrigate their crops. In view of predictions based on global warming trends, adapting to a drier climate (or at least a climate with greater risks of droughty conditions) will likely become a necessity. Irrigation of crops is likely to increase under this scenario and as such, sustainable water extraction policy and monitoring systems are required to ensure future supplies. On the farm, research is needed to quantify on-farm water cycles. The development of a research program to investigate the potential of alternative irrigation methods, such as surface drip irrigation and subsurface drip irrigation and controlled drainage, is necessary to better utilize water and nutrients in the production of crops. Crop production systems that incorporate micro-irrigation techniques may increase water-use efficiency through reduced evaporation losses, and improved scheduling which would result in a greater capacity for control of internal drainage and lower the incidence of disease compared with conventional irrigation. Furthermore, drip irrigation with fertigation may provide opportunities to use nutrients more efficiently and improve water quality, through better timing and placement of nutrients by potentially reducing losses by deep percolation and erosion. While limited, the evidence available generally supports the contention that alternative irrigation technologies can reduce the off-site effects of irrigated agriculture. However, there is a need to investigate how nutrients move through the soil matrix under these alternative irrigation methods. With the passing of the Nutrient Management Act, 2002, a set of new standards aimed at managing nutrient-containing materials by farmers, municipalities and others in the business will be implemented. Given the high potential impact that nutrient management planning will have on the Ontario agriculture industry, there is a need to develop economically and environmentally sustainable nutrient management strategies. There is a need to determine nutrient and irrigation water requirements for sustainable production of agricultural crops grown in Ontario. This work will provide important baseline data for the development of such nutrient management plans.

4. Soil and Crop Management

Research investigating the effects of soil management practices on chemical, biological and physical soil quality as related to crop production and environmental stewardship.

Soil is a critically important element of sustainable agricultural production, functioning not only in food and fibre production but also in maintaining local, regional and global environmental quality. High quality soils are not only more productive but also play a major role in enhancing air and water quality. Soil management practices, such as tillage, cropping pattern, and fertilization influence soil, water, and air quality. Past soil management for food and fibre production has taxed the resiliency of natural processes to maintain a balance of the cycling of energy and matter. Degradation of the soils productive capacity has occurred as a result of intensive agricultural production and resulting soil erosion, atmospheric pollution, cultivation and land clearing. Water quality is jeopardized by our choices in soil management and the consequent imbalance of C and N cycling in the soil. The present threat of global climate change and soil management issues dealing with carbon sequestration and the reduction of greenhouse

gas emissions warrants a better understanding of the effects of soil management on soil processes.

Assessing soil quality and its impacts on productivity and the environment is complicated since research must consider the multiple functions of soil and integrate the physical, chemical and biological soil attributes that define soil function. However, to achieve the goals of high crop yields and quality with minimal environmental impact requires reliable research information that assesses the impact of management on soil quality and on soil use. In addition, the fundamental requirements of profitability and competitiveness must be incorporated into the overall soil management strategy.

5. Identification / Validation of Best Management Practices

Research directed towards the implementation, validation (including cost/benefit analysis) of Best Management Practices, as related to the other identified Priority Issues.

A "Best Management Practice" (BMP) is defined as a practical and affordable approach to conserving and utilizing in an environmentally responsible manner a farm's soil and water resources without sacrificing productivity. The agricultural community has been encouraged to use, and are using, different types of environmentally related BMPs to protect and improve surface and ground water resources on both a farm and watershed scale. Reduction of the entry of phosphorus, nitrogen, pesticides, pathogens and sediment into water resources has been the main focus of the BMPs. The development of nutrient management plans rely heavily on BMP's for criteria related to nutrient applications (both inorganic and organic sources) and crop management systems. While most BMPs are based on research findings, some have not been tested at various scales and the net effect of combinations of BMPs is unknown. Scaling problems will always be an issue, and until better scaling methodologies are developed, it will be difficult and risky to interpret BMP validation data at scales other than at which the information was collected. Effectiveness of combinations of BMPs is particularly important when one considers the consequences of the ratification of the Kyoto Agreement and current issues surrounding water quality and quantity. For example a set of BMPs that effectively minimizes nitrate leaching or soil erosion may promote greenhouse gas emissions.

Greater acceptance of BMPs by the agricultural community requires validation of the BMPs achieving the desired outcome (i.e. risk reduction), the cost/benefit analysis associated with the practice, and the effective communication of this information to the producer.

6. Biosolid / Waste Application and Treatment

Research investigating biosolid/waste treatment and management methods resulting in the reduction of contaminant transport off-site while improving nutrient use efficiency and crop production.

Controversy surrounds the utilization of biosolids and other waste materials on agricultural lands. While many of the issues such as nutrient availability, potential soil, water and air contamination with biosolids and waste materials are similar to those with manure, there are considerable differences in the range of properties associated with the materials involved. Biosolid/waste materials have the additional stigma as being waste materials that are imported to and disposed of on agricultural lands, rather than a valuable source of nutrients and organic matter additions to the soil. Biosolids are known to improve soil physical, chemical, and biological characteristics and have the potential to enhance crop yields. At the same time, public health and environmental concerns regarding objectionable odours, chemical contaminants and pathogens present a challenge for the safe handling and application of these wastes materials. Concentrations of nutrients in these materials vary both over time and among treatment

methods. Increased public concern over the odours, potential transmission of pathogens and nutrients into surface and ground water as well as into the food chain has generated interest in the use of biosolids that have been subjected to some form of treatment to reduce these problems. There is a need to investigate the effect of different management methods and treatments for these organic amendments on the control of odours, reducing the number of potential pathogens and maintaining their nutrient content for the production of agricultural crops grown in Ontario.

7. Rural Air Quality

Research addressing the interactions between agricultural practices and rural air quality.

The rural air quality issue is a double-edged sword, with air quality (pollution) impacting upon crop production, while agricultural practices may also affect air quality (usually odours from livestock operations, manure and biosolid applications). The past two growing seasons have been characterized by an increase incidence of "smog days", extending beyond the typical urban areas into the rural communities. Air pollution injury has been observed on susceptible crop species, and may have been a contributing factor to yield and quality reductions in these crops. The effect of air pollution on crops is an area that is not well understood and needs to be monitored.

Manure and biosolid odour problems have been the major air quality issue of the rural populace, leading to a large number of confrontations between agricultural and non-agricultural groups. As mentioned previously in Priorities Issues 1 and 6, research regarding the management of organic sources of nutrients should include methods to minimize odour problems during storage and application.

8. Greenhouse Gas Emissions / Climate Change

Research assessing the manner in which agriculture can mitigate climate change, the impact of climate change on agriculture and the adaptation of agriculture to climate change.

Agriculture is undoubtedly one of the most sensitive sectors to climate change, but also highly amenable to intervention of climate change through the mitigation of greenhouse gas (GHG) emissions. Agriculture is a major source of nitrous oxide and methane emissions, although it can also serve as a potential sink for carbon dioxide. Assessment of the fluxes of these gases from various agricultural systems is required to truly understand the potential impact that alternative management strategies may have on total GHG emissions. Such an assessment would also involve the ability to model and scale results up from a farm to regional/ecozone or national scale.

The current trend in climate warming, whether attributable to GHG emissions or a natural phenomenon, may have significant impact on Ontario agriculture. Analysis of historic climatic data suggests that the period of time from the 1950-1980 actually

represented a period of relatively unusual stable climate. The recent variations in weather within and between years experienced in the past decade or so may actually be more indicative of 'normal' weather conditions. Consequently, growing season lengths, precipitation (amount and distribution), and temperatures are more likely to increase in variability. These changes could bring about changes in the winter survivability of perennial plants and certain pests. As a result, production systems and practices must adapt to these greater extremes if large-scale crop failures are to be avoided. For example, hotter and drier growing season conditions may increase the need for irrigation and irrigation methods that improve water use efficiency.

Strategic Research Recommendations

The following strategic research recommendations have been partitioned according to their level of priority (high, medium or low) and identified as to which Priority Issue(s) they address.

1. High Priority Strategic Research Recommendations

Note: These are listed in order of main PRIORITY ISSUE.

Recommendation H1: Nitrogen and Phosphorus Management of Manure and Biosolids to Minimize Losses and to Maximize Availability to Field and Horticultural Crops.

ISSUE: Manure Management, Nutrient Use Efficiency, Biosolid/Waste Application and Treatment

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Animal Research and Services Committee
Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario
Canadian Agri-Food Research Council

Background:

In the past number of years nutrient management plans have attempted to match nutrients from land applied organic materials to meet crop needs. The results have reduced over application of nutrients and reduced the risk of environmental contamination, mostly to surface water. However, there is much “fine-tuning” required in better understanding the nitrogen and phosphorus cycles in the organic materials, as well as how these cycles change once the material is applied to the soil under various application systems and over a number of years. How does the nitrogen cycle and availability of nitrogen change when manure is injected versus surface applied, for example? With phosphorus, the concern in Ontario has been largely from a surface water contamination perspective, and a P-Index was created to assess the risk of P movement based primarily on the risk of soil movement. Verification of the P-index, through field studies is required to ensure that the major mechanism of P movement to surface waters has been adequately characterized and the risk of P contamination of water suitably reduced. Under Ontario conditions, what are the mechanisms of

phosphorus movement? For example, is preferential flow the main pathway for phosphorus movement to tiles?

Part 1: Research is required in nitrogen management of manure and biosolids under various handling systems. Improving prediction of mineralization of liquid and solid materials, as well as the prediction of risk of N_2O production from the nitrification process (especially in conditions where excess ammonium is added to the soil) would help to time manure and biosolids applications to maximize utilization and decrease loss especially in groundwater recharge areas and sensitive groundwater area (i.e. shallow to bedrock soils). From a cropping perspective, additional research is required in determining how to improve nitrogen utilization considering timing, placement, use of cover crops and existing soil organic matter content, especially in horticultural crop production systems.

Part 2: There is a need for research to determine the effectiveness of cover crops for nutrient absorption and retention in fields that receive manure. Research can also be conducted to determine the rate that nutrients are released from the cover crops for subsequent crops. The research should include the optimum types of cover crops for application of manure at different times of the growing season and different types of manure. This research is needed to improve nutrient management planning.

Part 3: Research is required to better understand, and manage through BMPs, the mechanisms of phosphorus movement in Ontario soil conditions, especially as phosphorus soil tests increase from continuous manure application. In addition, the crop availability of phosphorus from biosolids undergoing different treatments needs to be better understood.

The benefit of the above research would be that it would help to provide better prediction of nutrient application options in nutrient management planning for manure and biosolids. Research would also potentially help identify which (sometimes contradictory) BMP would be best under specific field/soil/farm conditions.

Recommendation H2: Effect on Nutrient Availability, Pathogen Reduction, Greenhouse Gas Emissions and Economics of Various Treatment Systems for Liquid and Solid Manure and Biosolids

ISSUE: Manure Management, Nutrient Use Efficiency, Biosolid/Waste Application and Treatment

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Animal Research and Services Committee
Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee
Engineering Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario
Canadian Agri-Food Research Council

Background:

Manure and Biosolids are under increasing scrutiny from society due to potential nutrient contamination and pathogen contamination of water sources. Increasing interest in alternative manure treatment systems is a result of increased public pressure combined with large liquid volumes and limited land base (in some areas of Ontario) for more manure/biosolid application. Liquid systems including anaerobic digesters, aerobic systems, and electrolysis of manure are being discussed and tried to evaluate pathogen, odour and nitrogen reduction potential. Solid systems including proper composting, sterilization and complete drying of manure are also being evaluated for odour, volume and pathogen reduction. From a mechanical point of view these systems can work.

Research is required to determine the effect of treatment systems on nutrient content and availability, pathogen reduction, as well as on various greenhouse gas emissions and odours. Although not as critical, the economics of these systems must also be considered (for example what is the cost of treatment versus the improvement in pathogen/nutrient/lack of greenhouse gas emissions). The economics play an important role in determining how economic instruments can be designed to evaluate the benefits (i.e. how much society could/should pay).

This research would benefit both livestock producers and rural landowners. Livestock producers with large liquid manure systems, especially in areas where land base is limited could reduce land base requirements for manure application. Manure/biosolid applicators and rural landowners would have decreased risk from nutrient and pathogen

contamination as well as reduced odours. A by-product of some treatment processes could also lead to the development of “green energy”.

Recommendation H3: Manure Application Systems: Timing, Nutrient Loading and Tillage Interactions.

ISSUE: Manure Management, Nutrient Use Efficiency, Soil and Crop Management, Biosolid/Waste Application and Treatment

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee
Engineering Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario
Canadian Agri-Food Research Council

Background:

Current research in Ontario addresses many issues associated with manure application, however, some areas of research require much more work. The timing of manure application in relation to the availability of nutrients from the manure is not completely understood. Manure is applied on frozen ground. The fate of the nutrients from manure applied on frozen soils in the environment has not been fully studied. Manure is applied at all other times of the growing season and the fate of nutrients in that manure is often not known.

Another manure application issue is nutrient loading. In some instances manure is applied at extremely high rates over many years. How much manure can be reasonably applied without losses of nutrients from the field to the environment? How can we best keep those nutrients in the soil that the manure was applied to? These are questions for which we need answers.

Reducing tillage may reduce the potential for runoff of manure and nutrient losses from fields. Research with manure application in reduced tillage conditions should be conducted to determine the optimum methods, rates and timing of applied manure in reduced tillage systems.

Recommendation H4: Nutrient management planning for horticultural crops

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

There has been minimal research in the past for calibration to determine fertilizer recommendations for horticultural crops grown on Ontario soils. Research is needed to establish “best” fertilizer practices (rates, timing, application methods, fertigation, macro- and micro- nutrients and formulations) for horticultural crops. This information is crucial to enhance the applicability of nutrient management plans to horticultural crop production. Research is needed to evaluate the effectiveness of these nutrients on the yield and especially the quality of horticultural crops.

Recommendation H5: New Nitrogen Recommendation Systems for Crops.

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background

Some areas of a field require no nitrogen, while other areas within a field require high rates of nitrogen, for optimum growth. This research recommendation is for creating methods of accurately predicting nitrogen requirements in different areas of fields for crops that require nitrogen. Current methods of predicting nitrogen needs within a field do not adequately account for nitrogen variation across a field. On-farm verification of recommended nitrogen fertilizer application rates should be included in the nitrogen recommendations system.

Recommendation H6: Nitrate N test for Horticultural Crops

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background

Research and fields trials are necessary to evaluate and calibrate a nitrate-nitrogen test for horticultural crops, particular in muck (organic) soils and a pre-sidedress nitrogen test for sweet corn. As well, field demonstrations are needed to evaluate quick test technology for nitrates in both mineral and muck soils. This technology is being used in other parts of the world (particularly North America) but has not been well studied in Ontario.

Recommendation H7: Standard methods for manure analysis

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES:

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Standard Methods for manure analysis (Total N, P, K, NH₄-N, Dry Matter) would be developed for Ontario laboratories. This would be accomplished in stages: First, survey labs for methods currently being used, and assessing differences and similarities. Second, complete a literature review to assess appropriateness of current methods. Third, exchange samples among labs to compare results from different labs.

Recommendation H8: Establish a Watershed Nutrient Loading Capacity and Identify Sources and Pathways of Contamination.

ISSUE: Water Management

SOURCE: Ontario Water Management Research and Services Committee
Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee
Engineering Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario
Ontario Ministry of the Environment

Background:

Policy should be established that outlines the total nutrient loading capacity of a watershed. If the loading capacity is exceeded then the amount of reduction necessary to achieve appropriate levels must be quantified. This policy would assist municipalities in developing a consistent and fair mechanism to aid in land use decisions. Inherent in the development of such policy is the need to characterize the transport pathways of phosphorus, nitrogen and pathogens over the soil surface and through the soil matrix to tile drains and the water table.

Part 1: From a monitoring perspective, research is required to identify surface water stress indicators related to excess nutrient load, as well as benchmark standards for tile water quality. Issues pertaining to scale of operation and losses (risk and amount) of contaminants are also of importance. Reliable methods are needed for identifying sources of contamination by pathogens and bacteria (e.g. DNA fingerprinting).

Part 2: From a predictive and modeling perspective research is required to identify pathways of pathogen, nutrient, pesticide and other contaminant and transport to groundwater. Information is also needed regarding the scale of farming operation versus risk and amount of leaching and runoff losses of contaminants.

Recommendation H9: Development and Establishment of a Sustainable Water Extraction and Sharing Policy, and a Monitoring System to Ensure Future Supplies are Protected.

ISSUE: Water Management

SOURCE: Ontario Water Management Research and Services Committee
Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee
Engineering Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario
Ontario Ministry of the Environment

Background

The quantity of groundwater and surface water supplies could be at risk in the future, especially if growth continues at the current rate and climatic changes bring more dry years. A sustainable water extraction policy and an adequate monitoring system are required to ensure that future supplies are available. The policy would assist planners in resolving issues in water use\overuse conflicts and could be used as a decision-making tool when assessing applications to take water. Inherent in this policy is the need to define or identify the water needs of the natural environment. One fundamental issue to address is what should be the main source of potable water (i.e. surface or groundwater). Ongoing research in efficient irrigation systems, timing of irrigations and reducing environmental impact from irrigation practices need continued support and development to promote the efficient use of this potentially limited resource.

Recommendation H10: Development of Best Management Practices (BMPs) to Deal With Pathogens and Other Contaminants (Bioaerosols, Endocrine Disrupters, Antibiotics, Pharmaceuticals, Heavy Metals etc) in Manures and Biosolids

ISSUE: Identification/Validation of Best Management Practices
Manure Management
Biosolid/Waste Application and Treatment

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Animal Research and Services Committee
Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee
Engineering Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

In the development of nutrient management standards for application of manure and biosolids, the different materials are often compared from a nutrient equivalent. The media attention from pathogen contamination of water from organic materials has put into question how these materials should be compared from a risk perspective. Other contaminants being questioned (and measured?) in organic materials include all pathogens (not just indicators such as coliform or ecoli), endocrine disrupters, antibiotics, pharmaceuticals, and bioaerosols, etc.

Research is required to better answer some of the following questions around contaminants in organic materials.

Part 1: Research is required to better understand the various pathogens in organic materials. For example: How can we limit the survival of pathogens applied to land, and prevent pathogen transport in preferential flow channels? How can we separate the sources of pathogens in surface water bodies to effect implementation of BMPs? What are the maximum daily loads of contaminants that we can allow into our water resources, and have a sustainable program for the use of the resources? And finally, what actions do we need to prevent the cycling of pathogens between humans and animals?

Part 2: Research is required to better understand the impacts so that BMPs can be developed for applying waste on agricultural land when the waste contains antibiotics, hormonally active compounds, bioaerosols or other pharmaceuticals.

Benefits of this research would increase the confidence of Ontario residents that the application of organic materials is safe from both a nutrient and “other contaminant” point of view. It would also help to determine treatment and or application measures for materials of “different qualities”.

Recommendation H11: Best Management Practices Economic and Environmental Cost-Benefit Analysis

ISSUE: Identification/Validation of Best Management Practices
Manure Management
Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Animal Research and Services Committee
Field Crops Research and Services Committee
Engineering Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background

Rural water quality “Best Management Practices”, including alternative livestock manure storage, nutrient management plans, partial, seasonal and complete livestock access restriction, innovative rural septic beds, urban stormwater runoff controls, riparian buffer strips, vegetative filter strips, wetlands and other practices all vary in terms of cost and the anticipated water quality benefit. A thorough assessment of anticipated benefit and cost would provide some guidance in prioritizing activities for the source protection plans proposed in the Walkerton Report. The end product should be an analysis of options based on \$/kg phosphorus or \$/E.coli bacteria.

Development and testing of BMPs for liquid and solid manure application timing and methods in terms of pathogen and nutrient fate is required. Alternatives to land application of manure and condensing of liquid manure such as use of organic bedding material and composting need to be investigated. Pilot-scale testing of new methods of managing/utilizing liquid manure such as composting, condensing, pre-treatments, energy from manure (e.g. methane digestion) will be required to ensure suitable success with the technology at the farm level. In addition, the effectiveness of different types of injection/incorporation equipment and new controlled rate application technologies (flow meters with injection booms) vs. current methods in terms of crop response and environmental risk (leaching losses of nutrients, pathogens, feed supplements (growth hormones, antibiotics)) need to be assessed as well as methods to utilize manure under no-till crop production systems.

Recommendation H12: To continue to support the measurement and modelling of greenhouse gases emissions, quantify emissions of these gases from agricultural activities and to expand the work on atmospheric transport of gases.

ISSUE: Rural Air Quality and Greenhouse Gas Emissions

SOURCE: Ontario Agrometeorology Research and Services Committee

OASCC LINKAGES: Animal Research and Services Committee
Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee
Engineering Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario
Environment Canada
Canadian Agri-Food Research Council

Background:

Part 1

The recent ratification of the Kyoto Protocol has raised many questions as to the role that agriculture will ultimately play in helping Canada meet its targeted emissions. Research is still required on the overall impact of management practices on carbon sequestration, as well as carbon dioxide and nitrous oxide emissions in order to truly assess the net impact of management practices and crop production levels on greenhouse gas emissions within a farming system, especially those utilizing nitrogen and organic materials (manures, biosolids etc.).

Part 2

Research is also required in the area of diffusion/dispersion of various gasses (e.g. odours) in agricultural situations for development of practices and guidelines to minimize conflicts between agricultural producers and the rural community.

2. Medium Priority Strategic Research Recommendations

Recommendation M1: Temporal and Spatial Variability of Soil Properties in Agricultural Fields.

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Field variability of nutrient levels, pH, variable response to fertilizer and yields has created many new challenges to farmers. Strategies for optimizing inputs to deal with field variability are needed to optimize production on fields. The variables that affect yield most need to be identified along with cost effective, efficient ways of measuring those variables. With increased use of yield monitors in combines, management of soil variability is becoming a greater issue.

Current research in Ontario is concentrating on nitrogen and varying nitrogen rates across the field. The effects of variable population, phosphorus, potassium, weed control and lime, to name just a few, on yield variability are currently unknown. Much more needs to be learned.

Recommendation M2: Fertility Management for Improved Yield and Quality of Corn, Soybeans, Cereals and Canola.

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

More farmers are using site-specific technology and other new crop production methods. New ways of managing fertility with the common field crops in Ontario need to be investigated. Recent research elsewhere has suggested some important contributions of nutrients to cereal nutrition. Specifically, there may be some benefits to K top-dressed on winter wheat and chloride on cereals and their effects on yield and quality. Canola fertility has lagged even further behind to the point that P and K need more study, along with micronutrients.

Recommendation M3: Integration of Research Results into the Development of Information Systems and Decision Tools for Nutrient Management.

ISSUE: Identification/Verification of best Management Practices
Nutrient Use Efficiency
Manure Management
Biosolids/Waste Application and Treatment

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Every farmer using nutrients will require a nutrient management plan within the next decade. Nutrient management issues have and are resulting in more and diversified research into all aspects of nutrient use as well as potential environmental losses. Tracking farm nutrient data using land base management tools and computerized GIS systems are components being incorporated into nutrient management planning. The end goal is an effective, relatively simple and economic document.

As research is completed in various areas of nutrient management, there is a need to integrate and verify the research and field results using software models (such as M-Clone).

Benefits include increased confidence that all factors researched independently will, when combined, result in nutrient management plans that are “doable” and will have the intended or desired effect from an environmental protection perspective.

Recommendation M4: Development of a Method to Conduct and Present Scientific Research to the Public

ISSUE: Identification/Verification of best Management Practices
Nutrient Use Efficiency
Manure Management
Biosolids/Waste Application and Treatment

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Manure and biosolids and their production and application have created many conflicts within neighbourhoods and communities. If the smell would disappear, the issue would be largely reduced. Concerns around ground water study results, recharge areas, pathogen contamination to name a few, have resulted in municipalities creating bylaws to stop or slow down large livestock operations and/or the application of biosolids. When emotions run high around “a nutrient management issue” there is nothing to be gained by the “public” in being reasonable about science when trying to fight against the issue. At the same time it is not “the public’s” responsibility to find the solutions.

Consideration must be given to how scientific studies are conducted and reported so that “the public” has the “education” to make an informed decision.

The benefit of more reasonable debate over issues around nutrient management would improve understanding and relations between large livestock (and small livestock) operations and their non-farm, rural neighbours.

Recommendation M5: Development of tests and procedures for predicting nutrient release and availability from manures and biosolids.

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food

Background:

Part 1 Predicting N availability from manure: Develop methods to improve the prediction of nitrogen availability from manure, and studies should include: the effect of sample handling, storage and preparation on analytical results; the assessment of the proportion of ammoniacal N in manure samples that is volatile; and an improved prediction of the availability of N from the organic fraction.

Part 2 Predicting P availability from manure and biosolids: Assess the phosphorus availability from manure and biosolids, and develop improved methods for predicting this availability.

Recommendation M6: Development of management practices to improve the physical and biological quality of the soil.

ISSUE: Soil and Crop Management

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Research into how management factors such as crop rotation, tillage, soil compaction, and fertilization affect soil quality factors such as soil strength, structure, bulk density, water storage and transmission is required. Support for maintaining long term plots is essential to complete this research.

Cover crops are still minimally utilized in fruit and vegetable production in Ontario. Research is needed to determine the best systems to incorporate cover crops into annual vegetable production systems and to determine the best sequences of crops in these systems. Also, ongoing trials and research are necessary to compare cover crops and organic amendments and their effects on soil nematode populations.

Recommendation M7: Municipal Well Head Protection and Groundwater Vulnerability Criteria.

ISSUE: Water Management

SOURCE: Ontario Water Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario
Ontario Ministry of the Environment

Background:

Municipalities across Ontario are compiling wellhead protection and groundwater vulnerability maps based on characteristics such as depth to bedrock, physiography, depth to water table, extent of aquifers and recharge rates. Designation of protected and vulnerable groundwater areas may have a significant impact on crop management and livestock agriculture and therefore there is a need to develop fair land use designation tools. Designation criteria must be based on sound scientific and risk management principles to designate sensitive and vulnerable areas. Rural development strategies should be assessed to limit the number of new water wells and promote the use of innovative septic systems.

Recommendation M8: Continue to support the development and testing of weather based predictive models.

ISSUE: Greenhouse Gas Emissions and Rural Air Quality

SOURCE: Ontario Agrometeorology Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Continue to support the development and testing of weather based predictive models for: use in applications such as pest/disease management, nutrient management, crop growth models and irrigation scheduling. Models need to include wide area to site-

specific predictions depending on the needs of the crop and grower. A better understanding of water budgets, supply and estimating potential evaporation for use in irrigation scheduling models is required.

Recommendation M9 **Continue to quantify the benefits and detriments of climate change on Ontario agriculture and how to adapt to increased variability.**

ISSUE: Greenhouse Gas Emissions and Rural Air Quality

SOURCE: Ontario Agrometeorology Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
 Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
 Agriculture and Agri-Food Canada
 University of Guelph
 Agricultural Research Institute of Ontario

Background:

Trends in weather suggest that we are experiencing an increase in weather variability, with increased incidences of hot (>30 C) days and more infrequent rainfall. Crops will vary in their tolerances to these conditions. Studies are required to quantify the impact, benefits and detriments of climate change and how to adapt to climate change and increased variability. Adaptation will require improved crop management systems, including cultivars adapted to warmer, more variable climate. This work is required to maintain sustainability and security of food supply for Canadians.

3. Low Priority Strategic Research Recommendations

Recommendation L1 Site specific management and its use in the Horticultural Crop Industry.

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Research is needed to validate and adapt the new technology and includes such things as remote sensing, G.P.S. mapping and yield monitoring to the horticulture industry.

Recommendation L2 Soil pH and liming

ISSUE: Nutrient Use Efficiency
Soil and Crop Management

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

With the release of new, pH sensitive herbicides increased emphasis should be placed on soil pH and liming research. Recent work has indicated that soil pH may not be corrected to the target levels with the addition of recommended rates of lime. Research is needed to assist in identifying those parts of a field with pH problems and to find appropriate and accurate methods of correcting the soil pH.

Recommendation L3 Manganese index review

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Re-visit the manganese index as a tool for predicting the requirement for manganese fertilizers, to address concerns about responsive soils that are not identified by the index.

Recommendation L4 Effect of N and Ca on tobacco yield and quality

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Adjustments in nitrogen application have a greater effect on yield and quality of flue-cured tobacco than any other nutrient. While high rates of nitrogen generally result in high levels of leaf yield, leaf quality usually declines after excessive amounts of nitrogen have been applied. The timing of nitrogen application also plays a crucial role in crop response to nitrogen. Studies are needed to determine the effects of variations in nitrogen application rate and timing on agronomic performance and leaf quality.

Calcium application is believed to help in reducing various leaf problems, including bruising. Often some growers apply calcium fertilizers such as gypsum (CaSO_4) to the soil at transplanting and others apply foliar sprays of fertilizer formulations to supply extra calcium to the crop. The effects of calcium applications on agronomic performance and leaf quality need to be investigated.

Specifics included in this research work include: i) Determine the effects of nitrogen amount and timing on agronomic performance and leaf chemistry levels. ii) Determine the causes and solutions for bruised green tobacco. An area of potential investigation is the effect of calcium when applied at transplanting, side dressing, and/or as a foliar application with sucker control on agronomic performance including the incidence of bruise green. iii) Investigate nitrate levels resulting from both organic and inorganic sources as it relates to water quality.

Recommendation L5 Establish Guidelines for Site Investigations and Continued Monitoring of Proposed Intensive Farming Operations and Biosolids Application.

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
 Horticultural Crops Research and Services Committee
 Engineering Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
 Agriculture and Agri-Food Canada
 University of Guelph
 Agricultural Research Institute of Ontario

Background:

Current guidelines for investigating potential contamination of groundwater and surface water from existing and proposed farming operations have not been firmly established. Approved methods and levels of intensity of investigations need to be developed. This information would provide farmers, municipalities, Provincial government bodies, etc. with tools to determine consistent and fair approaches for site investigations.

Suggested Research Topics:

Determine the most cost-effective method to assess impacts of large-scale farming operations and biosolids application, investigate use of non-intrusive methods of soil and groundwater characterization; if monitoring wells are required, how many to install, and are existing databases adequate to determine potential impacts. Establish minimum frequency of groundwater and surface water samplings required to monitor large-scale farming operations and biosolids application.

Recommendation L6 Quantify Current and Future Farm- and Watershed-Scale Hydrologic Water Cycles.

ISSUE: Water Management

SOURCE: Ontario Water Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee
Engineering Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

The water budget of a farm divides the received precipitation into four basic components: evapotranspiration, runoff, drainage, and soil storage. The amount of water that each component accounts for impacts not only water quantity but also water quality issues. There is a lack of information available for different regions of Ontario on how water is partitioned into the four basic components given above. This information could assist farmers, planners, etc. in resolving current and future land use issues, site investigations for contaminant source identification, and resolving conflicts in water sharing.

Suggested Research Topics:

Determine the potential impacts of climate change on water surplus and deficits in the future for different regions in Ontario using computer simulation models. Quantify water pathways including runoff, tile drainage, deep drainage, and evapotranspiration, including the winter season. Determination of methods to allow scaling-up from field to farm to watershed levels.

Recommendation L7 Nutrient demand for new harvest systems

ISSUE: Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Nowadays a growing number of tobacco farmers have moved from hand harvesting of tobacco towards the path of harvesting with automatic harvesters. However, plant populations and spacing that are used under the two management systems are different, and it is not known whether the soil fertility requirements of plants for hand priming are applicable to those intended for machine harvesting. The effects of varieties and disease pressure with various plant populations, on tobacco yield and quality are also not clear.

Recommendation L8 Impacts of Alternative Irrigation Methods on Tobacco Production

ISSUE: Water Management
 Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
 Agriculture and Agri-Food Canada
 University of Guelph
 Agricultural Research Institute of Ontario

Background:

Irrigation is a major input for flue-cured production in Ontario. Tobacco irrigation is achieved with stationery and traveling gun sprinklers. There is growing interest in water conservation, ease of irrigation application, and fertigation programs to improve efficiency of fertilizer application. Results from the horticultural industry indicate that drip irrigation could be used as a means of meeting these concerns. Studies will be conducted to determine whether drip irrigation will provide a feasible alternative for tobacco farmers.

Recommendation L9 Crop Water Management for Increased Yield and Improved Water Quality

ISSUE: Water Management
 Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
 Agriculture and Agri-Food Canada

Background:

Subirrigation, irrigation, controlled drainage and fertigation all have shown some promise in Ontario. More research is needed to determine the economic and environmental sustainability of these crop production practices with common Ontario field crops.

Recommendation L10 Impacts of Organic Wastes and Biosolids on Horticultural Crop Production

ISSUE: Biosolid/Waste Application and Treatment
Nutrient Use Efficiency

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

There is ongoing interest in using various waste organic amendments in the horticulture industry by both the waste handlers and growers. Continued research is required to determine the effectiveness and adaptability of these amendments to horticultural production. It is also necessary to determine the effects of potential detrimental products in these amendments such as heavy metals, salts or other chemicals.

Recommendation L11 Compaction Reduction and Amelioration

ISSUE: Soil and Crop Management

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph

Agricultural Research Institute of Ontario

Background:

Research should be conducted into methods of reducing and avoiding compaction, which are suited to Ontario equipment and circumstances. Current recommendations are good for compaction avoidance, however, we need more research on ameliorating compaction already present.

Recommendation L12 Corn Cropping Systems

ISSUE: Soil and Crop Management

SOURCE: Ontario Soil Management Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

Much work has been done involving crop production systems with corn. However, some areas still require more work. The planting of no-till corn after winter wheat requires more study. Farmers have identified reduced emergence and plant stands and reduced yields related to growing no-till corn after winter wheat. Research to investigate residue management after winter wheat should continue.

Methods of coping with the increased residue on the soil surface and cooler moister seedbed conditions must be developed.

The use and benefits of cover crops in corn cropping systems could be addressed.

Lime issues related to no-till corn production should be addressed as well. Lime is relatively insoluble and immobile in the soil. In no-till production when the option of incorporating lime with tillage is no longer available, the efficacy of lime additions is not well documented.

Recommendation L13 Rural air quality and impacts of air pollution on crop yields and quality.

ISSUE: Rural Air Quality

SOURCE: Ontario Agrometeorology Research and Services Committee

OASCC LINKAGES: Field Crops Research and Services Committee
Horticultural Crops Research and Services Committee

TARGET AGENCY: Ontario Ministry of Agriculture and Food
Agriculture and Agri-Food Canada
University of Guelph
Agricultural Research Institute of Ontario

Background:

With increasing events of high temperature and lack of precipitation, an increasing number of air advisory warnings have been issued. These have expanded from typical urban areas to include rural areas. Visual symptoms of ozone damage has been observed on susceptible crops and there is a need to continue to monitor and accounted for damage in crop yields.

Recommendations Forwarded to Other Committees

The following Research Recommendations have been referred to the Ontario Field Crops Research and Services Committee (#1-4) and Ontario Horticultural Crops Research and Services Committee (#5)

1. Impacts of Alternative Crop Rotations on Tobacco yield and Quality

Preliminary tests conducted in Ontario have shown that some pearl millet cultivars can suppress root-lesion nematode (*Pratylenchus penetrans*) populations to levels that are comparable to those achieved with chemical fumigation. These tests have led to the consideration that pearl millet can be grown by tobacco farmers as an alternative cover crop. However, additional tests are needed to determine (a) the effectiveness of selected pearl millet cultivars for nematode control and (b) the effects of pearl millet rotation on yield and quality of the subsequent tobacco crop.

Specifics: i) Determine the effects of organic matter sources, particularly, sorghum, millet, and manure, on agronomic performance and leaf chemistry levels. ii) Determine if root-lesion nematodes can be controlled and pesticide use reduced through certain crop rotations.

2. Tillage Impacts on Tobacco Quality and Yield

There is some interest in conservation tillage practices for tobacco production in Ontario. The advantages of minimum tillage include reduced soil erosion and increased water use efficiency. This work will determine the management practices feasible for no-till cultivation of flue-cured tobacco in Ontario.

3. Impact of Soil Fertility on the Nutraceutical Qualities of crops.

Preliminary results have suggested a positive relationship between soybean isoflavone content and level of potassium fertility. Research should be conducted into the influence of potassium on the content of isoflavone in soybeans. Research looking at the effect of fertility on other functional food ingredients in crops is also needed.

4. Optimizing Soybean Production Under Shorter Soybean Rotations.

Farmers in the province are growing soybeans in very short rotations (if they use rotations at all). Studies to determine how to best maintain yields of soybeans should be conducted. The length of soybean rotations for preventing the build-up of pathogens such as rhizoctonia root rot and soybean cyst nematodes should be studied. The effects of soybean based rotations on soil structure and other properties could also be included. Much work was done with corn and many of the problems that were studied for corn must be studied for soybeans as well.

5. Impacts of Reduced Tillage in the Horticultural Industry.

There has been little adoption of reduced tillage systems for fruit and vegetable production. Research is still needed to identify the level of tillage reduction and the effect of plant residue on vegetable yields for Ontario conditions and soils.

Appendix

1. Ontario Soil Management Research and Services Committee Report
2. Ontario Water Management Research and Services Committee Report
3. Ontario Agrometeorology Research and Services Committee Report

**ONTARIO SOIL MANAGEMENT
RESEARCH AND SERVICES COMMITTEE**

2002 REPORT TO

**ONTARIO SOIL, WATER AND AIR
RESEARCH SERVICES COMMITTEE**

TABLE OF CONTENTS

Executive Summary	3
State of the Industry	4
Issues Scan	4
Committee Activities	6
Terms of Reference of the OSMRSC	6
Membership Representation	6
Member Responsibilities	7
Requirements for New or Revised Recommendations	8
Revisions to General N Recommendations for Corn	9
The Nitrogen and Phosphorus Indices	9
Average Crop Yield and N and P Removal Values for Use in NMAN Software	9
Strategic Directions: Research	11
Recommendation 1: Nutrient Management	11
Recommendation 2: Water Management	14
Recommendation 3: Manure and Biosolid Management	15
Recommendation 4: Manure and Biosolid Treatment	19
Recommendation 5: Soil Management and Soil Quality	21
Service Recommendations	24
OSMRSC Membership List	27

Executive Summary

The annual meeting of the Ontario Soil Management Research and Services Committee (OSMRSC) was held at the Greenhouse and Processing Crops Research Centre, Agriculture and Agri-Food Canada, Harrow, on June 11 and 12, 2002. Chairs of the various subcommittees and industry representatives submitted and presented reports to the committee outlining research progress, research and service priorities and changes to OMAF publications pertaining to field crop production, horticultural crop production, tobacco production, waste utilization, soil and water quality, and soil testing. A subsequent meeting was held on Oct. 23, 2002 at the Southern Crop Protection and Food Research Centre, Agriculture and Agri-Food Canada, London to discuss the mandate and responsibilities of the committee, various aspects of the Nutrient Management Act and additional revisions to OMAF recommendations.

Major issues of concern were nutrient management, efficient water use and water quality, manure treatment and management and soil quality. Gaps in research data to support nutrient management plans over the short term were a concern of all subcommittees. Again this year, this issue was a large concern of the Horticultural Crop subcommittee due to small amount of research data available for calibration to determine fertilizer recommendations for horticultural crops grown on Ontario soils. In general, solving this issue will require increasing the goals of production research to include the environmental impacts of management practices, the need for multi-disciplinary projects rather than smaller individual projects and the need for increased support of longer term research projects.

Research priorities for 2002 were grouped according to the following issues, listed in order of priority:

1. **Nutrient Management**
2. **Water Management**
3. **Manure and Biosolid Management**
4. **Manure and Biosolid Treatment**
5. **Soil Management and Soil Quality**

The higher priority given to issues dealing with nutrient and water management over issues dealing with manure and biosolid management and treatment is a major change from previous years and reflects the adoption of the Nutrient Management Act and drier than average cropping seasons during the past two years. However, many of the concerns that fall under the issue of manure and biosolid management also deal with nutrient availability and nutrient-use efficiency. Commodity or discipline specific research recommendations highlight the concerns of each of the individual subcommittee and the sector of agriculture that it represents. While not presented in this report, the amount of research effort currently underway was considered in the prioritization of the research needs. These research priorities, therefore, attempt to address these issues through both strategic, integrated approaches and individual targeted goals.

State of the Industry

Water quality continued to be a high-ranking issue in the public eye following the release of Commissioner Dennis O'Connor's report of the Walkerton Inquiry on 18 January, 2002. As part of the provincial governments pledge to ensure clean, safe drinking water in the province, the Nutrient Management Act was passed on June 27, 2002. The Act enhances the protection of Ontario's water resources by minimizing the effects of agricultural practices on the environment, especially as they relate to land-applied materials containing nutrients. Once implemented, the Act and associated Nutrient Management Plans and Strategies will form part of the water protection system envisioned by Commissioner O'Connor. However, details concerning implementation of the Act has raised concerns in both the scientific and farming communities. Concerns by agricultural researchers surround the short-term need for best management practices that improve nutrient use-efficiency and updated crop removal nutrient values for use in nutrient management plans. The implementation of the plan, while applauded by the agricultural community, has raised concerns regarding the impact of accountability on farmers, both in increased cost and in increased time commitment.

As was the case in 2001, high temperatures and low precipitation during much of the growing season led to low soil water availability throughout Ontario. This is expected to adversely affect crop production and will undoubtedly reduce crop yields. Throughout most of the growing season below average precipitation led to below average stream flows. As of 17 October, 2002, 16 Conservation Authorities in south central Ontario were in a confirmed low water condition with most stations reporting stream flows below 50% and several reporting 30% of average values. This situation persisted for most of the latter part of the cropping season. Since the main source of irrigation water for most crops has been local waterways, low stream flow and the availability of irrigation water is a concern to many growers. Low water availability in the future will undoubtedly impact the ability to supply additional water to crops with irrigation and will continue to remain an issue.

Issues Scan

The Ontario Soil Management Research and Services Committee (OSMRSC) addresses issues surrounding the impacts of soil management on the chemical, biological, and physical properties of soil, crop production and the environment. The subcommittee structure of OSMRSC is essentially commodity based but has a subcommittee that deals specifically with soil and water quality issues and a subcommittee that deals with soil testing issues.

Nutrient management, efficient water use and water quality, and manure treatment and management are the dominant issues that are a concern in soil management. Under the Nutrient Management Act, province-wide standards to address the effects of agricultural practices on the environment, especially as they relate to land-applied material containing nutrients will be developed and implemented. Stricter accounting of nutrient use, through the preparation of a nutrient management plan is a core element of the program. Livestock and concerns over manure management (odour, nutrients etc.) are the dominant reasons for requiring legislation

related to intensive farming operations. However, the application and management of all land applied nutrients are addressed in the act.

Sustainable crop production requires the integration of many complex components. Research must not only be aimed at providing information on the effects of individual soil and crop management practices on soil quality but must integrate the effects of each component of the system on soil quality. As a result, all soil related research should be carried through to the impact on tile water and/or groundwater. This will require increasing the goals of production research to include the environmental impacts of management practices. In some cases, research needs could be better served by large, multi-disciplinary projects rather than smaller individual projects. Increased communication with the other programs (Plant Program and Livestock Program) will undoubtedly enhance this effort. The establishment of multi-disciplinary teams will increase the requirement for co-ordination among project cooperators but will augment the knowledge database required to meet the current needs for information. Integration of the research would increase the efficient use of resources, but a number of challenges exist. These challenges include, 1. Effective communication among researchers. 2. Changing priorities in time often lead to repeating previously completed research that had not addressed environmental aspects. 3. Research programs are set out with specific goals and work plans. Shifts in research priorities to meet short-term and long-term research needs can result in changes in the priorities of the research personnel and have negative effects on the overall research program.

Many of the issues dealing with soil management strategies cannot be answered in a 3 or 4 year project, but rather, require long-term research. However, funding long-term research has been increasingly difficult or impossible. If sustainable soil and crop management strategies are to be developed based on reliable research data, it is important that funding agencies increase the amount of funding aimed at developing sustainable production practices through the funding of longer-term projects. Commodity groups also need to support the environmental aspects. This will probably begin when specific issues emerge that impact on the ability of the industry to remain viable. There is a need for matching funds to complete this work. Under special research guidelines, consideration must be given to determine whether all sources of outside funds has been considered rather than a fixed requirement for matching funds.

Farmers today face the dilemma of decreasing profit margins and increasing public concern about the impact of farming on the environment, especially air and water quality. Although high input agriculture with irrigation has favourably affected production, it is generally assumed that these conditions have degraded ground water quality. Understanding the effects of management on transport pathways of pesticides and nutrients and on nutrient cycling are important to understanding the impact of agriculture on water quality. Concern regarding impact of accountability on farmers, both increased cost and increased time commitment. Research that aims at developing sound, economically profitable, and socially acceptable farming systems and technologies must be initiated and supported. One of the criteria for funding must incorporate the difference between a priority that is considered "Urgent" versus one that is considered "Important". Often, if a research issue is considered urgent, it is probably already too late. Eg. Nutrient management research to support Bill 81.

Water quantity is also an issue, but concern generally arises in drought years. In both 2001 and 2002 growing seasons below average amounts of precipitation were received. This is a concern with both irrigated and non-irrigated crops.

The research priorities outlined below attempt to address these issues through both strategic, integrated approaches and individual targeted goals. They are presented in order from high to low priority.

Committee Activities

Terms of Reference of the OSMRSC

The Ontario Soil Management Research and Services Committee (OSMRSC) is a subcommittee of the the Ontario Soil, Water and Air Research and Services Committee, and answers to that committee. The OSMRSC and its constituent subcommittees are empowered to review and direct research and services leading to the improvement of soil and nutrient management practices that will lead to improved crop production, competitiveness of Ontario agriculture in world markets and minimize the impact of agricultural activities on the environment. Specifically the mandate of the committee is:

- To assist in bringing together farmer, industry, research, extension and regulatory personnel to discuss soil management issues in Ontario;
- To formulate recommendations concerning nutrient use and other soil management practices;
- To forward recommendations to the OMAF Accredited Laboratories and the OMAF Publications Committee after posting in accordance with the Environmental Bill of Rights and subsequent approval;
- To provide a forum for the exchange of research information and co-ordination of research efforts on soil management problems in Ontario;
- To define research requirements in relation to present and future needs and opportunities for development of the agricultural industry;
- To make recommendations to the Ontario Soil, Water and Air Research and Services Committee concerning the requirements and priorities for research and services; and
- To suggest ways of meeting the research and services requirements by:
 - Evaluating cost-benefits;
 - Recommending appropriate institutions to do the work;
 - Projecting resources needed; and
 - Describing how resources may be obtained or freed for the work
- To evaluate additions or deletions of member organizations as required

Membership Representation

Membership in the committee is set at 22 members and is made up of representatives from each of the following agencies.

Ontario Ministry of Agriculture and Food, Crop Technology
Ontario Ministry of Agriculture and Food, Crop Technology - Field Crops
Ontario Ministry of Agriculture and Food, Crop Technology - Horticultural Crops
Ontario Ministry of Agriculture and Food Resources Management
Ontario Ministry of Environment
University of Guelph - Land Resource Science
University of Guelph - Ridgetown
University of Guelph - Kemptville
University of Guelph - New Liskeard
University of Guelph - Department of Plant Agriculture
Agriculture & Agri-Food Canada - Southern Crop Protection and Food Research Centre, London
Agriculture & Agri-Food Canada – Greenhouse and Processing Crops Research Centre, Harrow
Agriculture & Agri-Food Canada – Eastern Cereal and Oilseed Research Centre, Ottawa
Chair – Waste Utilization Subcommittee
Chair – Field Crop Subcommittee
Chair – Horticultural Crops Subcommittee
Chair – Soil and Water Quality Subcommittee
Chair – Tobacco Subcommittee
Chair – Soil Test Lab Subcommittee
Ontario Agri-Business Association (2)
Ontario Soils and Crops Improvement Association (2)

Changes in membership may be recommended by the chair, subject to approval from OSWARSC.

Member Responsibilities

Chair:

To set the meeting date, meeting place, and deadlines for submissions
Recruit new members to the committee when needed
Notify committee members and Research Analyst, OMAF Innovation and Risk Management
Branch of meeting dates and deadlines
To chair the meeting, and to write the report for OSWARSC
Forward research priorities to the appropriate research and services committees
Attend and present report to OSWARSC
Length of term is 2 years

Vice-Chair:

Assume the role of the Chair if needed
Work with the Chair in finalizing the minutes and report
Be prepared to become Chair when the term of the Chair is finished

Secretary:

Take the minutes of the meeting
Distribute any minutes and reports to the committee membership
Work with the Chair and Vice-Chair in finalizing the minutes and report
Forward recommendations to the appropriate organizations and committees
Retain copies of the summary data presented to support recommendation changes, with links to the original source of data

Members:

Represent their organization or subcommittee, and report back to their group if needed
Review reports prior to the meeting
Attend and participate in discussions and decisions at the meeting
Make recommendations for replacement member if no longer able to be a member

Guests:

Guests may request to attend the meeting and participate in the discussions, but do not have voting privileges.

Ad Hoc Committees:

Ad hoc committees may be appointed by the chair, as required, to deal with specific issues. All such committees should provide a report to the main committee at the annual meeting.

Requirements for New or Revised Recommendations

Changes or additions to recommendations should be presented to and recommended by the applicable subcommittee, but may be considered by OSMRSC without this step. Supporting documentation must be provided to support any new or revised recommendations. This support may be in the form of either published or unpublished research.

Supporting data will be considered with the following priority:

1. Replicated trials from within Ontario
2. Unreplicated trials, in sufficient number, from within Ontario
3. Trials from jurisdictions with similar soil types and climate
4. Trials from elsewhere

Trial data must include enough information to allow the committee to assess the quality of the data, and the applicability to Ontario conditions.

In the absence of research data, and where time constraints do not allow the gathering of appropriate data, the opinion of recognized experts may be accepted as the basis for recommendations. Strong recommendations should be made that research be conducted to confirm the opinions of the experts.

Revisions to General N Recommendations for Corn

With the advent of the Nutrient Management Act, general N recommendations have taken on additional weight as the trigger for requiring further assessment of the N leaching potential from the soil. Since the optimum N rate will vary quite widely from field to field, because of variations in cropping history, soil type, previous fertilization, yield potential and drainage, the best solution is to develop systems for farmers to determine their own optimum N rates, as is being done in the site-specific project. However, general recommendations will always be needed as a starting point for this process, and need to be representative of the average field conditions. Data supporting an update for general N recommendations suggest that the optimum N rates are intermediate between those for Central and Southwestern Ontario. It was decided that Table 3-19 of OMAF publication 811 be amended to include nitrogen recommendations for the area in the 2700-2900 CHU zone that are intermediate to the rates in the areas on either side, as follows:

Table 3-19. General Recommended Nitrogen Rates for Corn

Region	Expected Grain Yield (t/ha)					
	6	7	8	9	10	11
	Most Profitable Nitrogen Rate (kg/ha of N)					
Eastern	90	110	130	155	175	200
Western and Central	100	110	120	125	135	140
2700 – 2900 CHU	130	140	150	155	165	175
South-Western Pre-Plant ²	160	175	185	190	200	210
South-Western Side-Dressed ²	140	145	150	155	160	165
100 kg/ha = 90 lb/ac			1 t/ha = 16 bu/ac			

The Nitrogen and Phosphorus Indices

The proposed N and P indices are risk management tools for reducing the probability of contaminating ground and surface waters with nutrients. The N index ranks the relative risk of ground water contamination resulting from N application on crop land whereas the P index ranks the relative risk of surface water contamination resulting from P application on crop land. The indices also allow a means to select management strategies that can be used to reduce these risks. After reviewing the content and application of the N and P indices, the OSMRSC approved the inclusion of the N and P indices in OMAF publications and the NMAN software.

Average Crop Yield and N and P Removal Values for Use in NMAN Software

The OSMRSC approved values for average provincial yields, and N and P crop removal tables submitted to the committee as starting points to be used in the NMAN software. The committee accepted the mandate of implementing revisions to the average provincial yield values for all crops. The process of determining revised average

provincial or regional average yield values will be based on the following order of acceptance:

1. Agricorp Statistics (5-year average)
2. OMAF Statistics
3. Appropriate Marketing Board Data
4. OMAF Commodity Specialist Data

The committee also accepted the mandate of implementing revisions to the nutrient removal values for all crops according to the following order of acceptance:

1. Ontario Research Data
2. Data from Jurisdictions with Similar Soil Types and Climate to Ontario
3. Other Sources of Valid Scientific Data (eg. Knott's Handbook)

Recommendations for changes, based on adequate supporting data, will be considered by the appropriate subcommittee, and recommended to OSMRSC for approval.

Strategic Directions: Research

Recommendation 1: Nutrient Management

Research assessing the effects of nutrient management on nutrient-use efficiency.

Concern over the impact of agricultural activity on the environment has increased in recent years. In the past decade, it has been repeatedly demonstrated that agriculture is a significant source of ground and surface water pollution. The problems associated with environmental contamination have led to policy and legislation that aims at effectively managing the land application of nutrients in an environmentally responsible manner. In general, the overall aim of a fertility program for crop production is to synchronize the availability of nutrients to uptake requirements of growing crops to reduce the risk of environmental contamination. However, a number of gaps in the existing knowledge are present. Nutrient requirements and application recommendations have been based on yield response with little emphasis paid to the environmental consequences or crop quality. In some cases, particularly in the horticultural industry, a database for calibration of fertilizer requirements to soil test values for both yield and quality is lacking. Field variability, cropping practices and differences in nutrient requirements of various crops, placement and time of requirement impact the overall nutrient management scheme. As a result of this concern, there is an urgent need to establish best management practices that involve establishing accurate nutrient requirements, proper application rates, timing, and methods of nutrient application that maintain the viability of the agricultural sector while minimizing the environmental impact.

Specific recommendations:

Nutrient management planning for horticultural crops - Horticultural Crop Subcommittee

There has been minimal research in the past for calibration to determine fertilizer recommendations for horticultural crops grown on Ontario soils. Research is needed to establish “best” fertilizer practices (rates, timing, application methods, fertigation, macro- and micro- nutrients and formulations) for horticultural crops. This information is crucial to enhance the applicability of nutrient management plans to horticultural crop production. Research is needed to evaluate the effectiveness of these nutrients on the yield and especially the quality of horticultural crops.

Nitrate N test for Horticultural Crops - Horticultural Crop Subcommittee

Research and field trials are necessary to evaluate and calibrate a nitrate-nitrogen test for horticultural crops, particular in muck (organic) soils and a pre-sidedress nitrogen test for sweet corn. As well, field demonstrations are needed to

evaluate quick test technology for nitrates in both mineral and muck soils. This technology is being used in other parts of the world (particularly North America) but has not been well studied in Ontario.

New Nitrogen Recommendation Systems for Crops. - Field Crops Subcommittee

Some areas of a field require no nitrogen, while other areas within a field require high rates of nitrogen, for optimum growth. This research recommendation is for creating methods of accurately predicting nitrogen requirements in different areas of fields for crops that require nitrogen. Current methods of predicting nitrogen needs within a field do not adequately account for nitrogen variation across a field. On-farm verification of recommended nitrogen fertilizer application rates should be included in the nitrogen recommendations system.

Effect of N and Ca on tobacco yield and quality – Tobacco Subcommittee.

Adjustments in nitrogen application have a greater effect on yield and quality of flue-cured tobacco than any other nutrient. While high rates of nitrogen generally result in high levels of leaf yield, leaf quality usually declines after excessive amounts of nitrogen have been applied. The timing of nitrogen application also plays a crucial role in crop response to nitrogen. Studies are needed to determine the effects of variations in nitrogen application rate and timing on agronomic performance and leaf quality.

Calcium application is believed to help in reducing various leaf problems, including bruising. Often some growers apply calcium fertilizers such as gypsum (CaSO_4) to the soil at transplanting and others apply foliar sprays of fertilizer formulations to supply extra calcium to the crop. The effects of calcium applications on agronomic performance and leaf quality need to be investigated.

Specifics included in this research work include: i) Determine the effects of nitrogen amount and timing on agronomic performance and leaf chemistry levels. ii) Determine the causes and solutions for bruised green tobacco. An area of potential investigation is the effects of calcium when applied at transplanting, side dressing, and/or as a foliar application with sucker control on agronomic performance including the incidence of bruise green. iii) Investigate nitrate levels resulting from both organic and inorganic sources as it relates to water quality.

Temporal and Spatial Variability of Soil Properties in Agricultural Fields. - Field Crops Subcommittee

Field variability of nutrient levels, pH, variable response to fertilizer and yields have created many new challenges to farmers. Strategies for optimizing inputs to deal with field variability are needed to optimize production on fields. The variables which affect yield most need to be identified along with cost effective, efficient ways of measuring those variables. With increased use of yield monitors in combines, management of soil variability is becoming a greater issue.

Current research in Ontario is concentrating on nitrogen and varying nitrogen rates across the field. The effects of variable population, phosphorus, potassium, weed

control and lime, to name just a few, on yield variability are currently unknown. Much more needs to be learned.

Site specific management and its use in the Horticultural Crop Industry - Horticultural Crops Subcommittee

Research is needed to validate and adapt this new technology which includes such things as remote sensing, G.P.S. mapping and yield monitoring to the horticulture industry.

Fertility Management for Improved Yield and Quality of Corn, Soybeans, Cereals and Canola. - Field Crops Subcommittee

More farmers are using site specific technology and other new crop production methods. New ways of managing fertility with the common field crops in Ontario need to be investigated. Recent research elsewhere has suggested some important contributions of nutrients to cereal nutrition. Specifically, there may be some benefits to K top-dressed on winter wheat and chloride on cereals and their effects on yield and quality. Canola fertility has lagged even further behind to the point that P and K need more study, along with micronutrients.

Soil pH and Liming - Field Crops Subcommittee

With the release of new, pH sensitive herbicides increased emphasis should be placed on soil pH and liming research. Recent work has indicated that soil pH may not be corrected to the target levels with the addition of recommended rates of lime. Research is needed to assist in identifying those parts of a field with pH problems and to find appropriate and accurate methods of correcting the soil pH.

Manganese index review - Soil Test Subcommittee

Re-visit the manganese index as a tool for predicting the requirement for manganese fertilizers, to address concerns about responsive soils that are not identified by the index.

Impact of Soil Fertility on the Nutraceutical Qualities of crops. - Field Crops Subcommittee

Preliminary results have suggested a positive relationship between soybean isoflavone content and level of potassium fertility. Research should be conducted into the influence of potassium on the content of isoflavone in soybeans. Research looking at the effect of fertility on other functional food ingredients in crops is also needed.

Nutrient demand for new harvest systems – Tobacco Subcommittee

Nowadays a growing number of tobacco farmers have moved from hand harvesting of tobacco towards the path of harvesting with automatic harvesters.

However, plant populations and spacing that are used under the two management systems are different, and it is not known whether the soil fertility requirements of plants for hand priming are applicable to those intended for machine harvesting. The effects of varieties and disease pressure with various plant populations, on tobacco yield and quality are also not clear.

Recommendation 2: Water Management

Research leading to more efficient methods of delivering water to growing crops and determining transport pathways of nutrients and pathogens to surface and subsurface water.

Recent dry weather and increased use of supplemental water to produce crops has lowered water levels in ponds, wells, creeks and the Great Lakes. Due to water shortages, provincial ministries are enforcing water use permits and growers are under the watchful eye of the public as they irrigate their crops. In view of predictions based on global warming trends, adapting to a drier climate will likely become a necessity. Irrigation of crops will likely increase under this scenario. The development of a research program to investigate the potential of alternative irrigation methods, such as surface drip irrigation and subsurface drip irrigation and controlled drainage, is necessary to better utilize water and nutrients in the production of crops. It is expected that a crop production system that incorporates micro-irrigation techniques would increase water-use efficiency through reduced losses to evaporation, improved scheduling, result in a greater capacity for control of internal drainage and lower the incidence of disease compared with conventional irrigation. Furthermore, drip irrigation with fertigation may provide opportunities to use nutrients more efficiently and improve water quality, through better timing and placement of nutrients and also reduced losses by deep percolation and erosion. While limited, the evidence available generally supports the contention that alternative irrigation technologies can reduce the off-site effects of irrigated agriculture. However, there is a need to investigate how nutrients move through the soil matrix under these alternative irrigation methods. With the passing of the Nutrient Management Act, 2002, a set of new standards aimed at managing nutrient-containing materials by farmers, municipalities and others in the business will be implemented. Given the high potential impact that nutrient management planning will have on the Ontario agriculture industry, there is a need to develop economically and environmentally sustainable nutrient management strategies. There is a need to determine nutrient and irrigation water requirements for sustainable production of agricultural crops grown in Ontario. This work will provide important baseline data for the development of such nutrient management plans.

Specific recommendations:

Efficient use and quality of water - Horticultural Crops Subcommittee

Communities and horticulture production need reliable, high quality water. Ongoing research in efficient irrigation systems, timing of irrigations and reducing

environmental impact from irrigation practices need continued support and development.

Crop Water Management for Increased Yield and Improved Water Quality - Field Crops Subcommittee

Subirrigation, irrigation, controlled drainage and fertigation all have shown some promise in Ontario. More research is needed to determine the economic and environmental sustainability of these crop production practices with common Ontario field crops.

Impacts of Alternative Irrigation Methods on Tobacco Production - Tobacco Subcommittee

Irrigation is a major input for flue-cured production in Ontario. Tobacco irrigation is achieved with stationery and traveling gun sprinklers. There is growing interest in water conservation, ease of irrigation application, and fertigation programs to improve efficiency of fertilizer application. Results from the horticultural industry indicate that drip irrigation could be used as a means of meeting these concerns. Studies will be conducted to determine whether drip irrigation will provide a feasible alternative for tobacco farmers.

Transport pathways - Soil and Water Quality Subcommittee

Research is needed to characterize the transport pathways of phosphorus, nitrogen and pathogens over the soil surface and through the soil matrix to tile drains and the water table.

Recommendation 3: Manure and Biosolid Management

Research investigating manure and biosolid management methods that reduce nutrient and contaminant transport off-site while improving nutrient use efficiency and crop production.

Controversy surrounds the management of livestock manure and biosolids on many Ontario farms. Increasing public concerns regarding environmental protection are requiring farmers to be increasingly careful of how manures and biosolids are handled in order to eliminate, or at least minimize, leakages of plant nutrients and pathogenic microorganisms from the farming system. Managed properly, livestock manures and biosolids can supply an important part of the farmer's crop nutrient needs without damaging the environment. Farm decision-makers must therefore balance the technical aspect of using these materials as a source of plant nutrients with the environmental aspect of avoiding damage. Moreover, organic amendment management must be thought of as only one aspect of overall farm management. Handling operations must

be combined with livestock and crop production and marketing plans, rather than being treated as separate entities.

Specific recommendations:

Pathogen and Contaminant Management in Biosolids and Manure. Development of Best Management Practices (BMPs) to Deal With Pathogens and Other Contaminants (Bioaerosols, Endocrine Disrupters, Antibiotics, Pharmaceuticals, Heavy Metals etc). - Waste Utilization Subcommittee

In the development of nutrient management standards for application of manure and biosolids, the different materials are often compared from a nutrient equivalent. The media attention from pathogen contamination of water from organic materials has put into question how these materials should be compared from a risk perspective. Other contaminants being questioned (and measured?) in organic materials include all pathogens (not just indicators such as coliform or ecoli), endocrine disrupters, antibiotics, pharmaceuticals, and bioaerosols, etc.

Research is required to better answer some of the following questions around contaminants in organic materials.

Part 1: Research is required to better understand the various pathogens in organic materials. For example: How can we limit the survival of pathogens applied to land, and prevent pathogen transport in preferential flow channels? How can we separate the sources of pathogens in surface water bodies to effect implementation of BMPs? What are the maximum daily loads of contaminants that we can allow into our water resources, and have a sustainable program for the use of the resources? And finally, what actions do we need to prevent the cycling of pathogens between humans and animals?

Part 2: Research is required to better understand the impacts so that BMPs can be developed for applying waste on agricultural land when the waste contains antibiotics, hormonally active compounds, bioaerosols or other pharmaceuticals.

Benefits of this research would increase the confidence of Ontario residents that the application of organic materials is safe from both a nutrient and “other contaminant” point of view. It would also help to determine treatment and or application measures for materials of “different qualities”.

Nitrogen and Phosphorus Management of Manure and Biosolids to Minimize Losses and to Maximize Availability to Field and Horticultural Crops. - Waste Utilization Subcommittee

In the past number of years nutrient management plans have attempted to match nutrients from land applied organic materials to meet crop needs. The results have reduced over application of nutrients and reduced the risk of environmental contamination, mostly to surface water. However, there is much “fine-tuning” required

in better understanding the nitrogen and phosphorus cycles in the organic materials, as well as how these cycles change once the material is applied to the soil under various application systems and over a number of years. How does the nitrogen cycle and availability of nitrogen change when manure is injected versus surface applied, for example? With phosphorus, the concern in Ontario has been largely from a surface water contamination perspective, and a P-Index was created to assess the risk of P movement based primarily on the risk of soil movement. Verification of the P-index, through field studies is required to ensure that the major mechanism of P movement to surface waters has been adequately characterized and the risk of P contamination of water suitably reduced. Under Ontario conditions, what are the mechanisms of phosphorus movement? For example, is preferential flow the main pathway for phosphorus movement to tiles?

Part 1: Research is required in nitrogen management of manure and biosolids under various handling systems. Improving prediction of mineralization of liquid and solid materials, as well as the prediction of risk of N₂O production from the nitrification process (especially in conditions where excess ammonium is added to the soil) would help to time manure and biosolids applications to maximize utilization and decrease loss especially in groundwater recharge areas and sensitive groundwater area (ie shallow to bedrock soils). From a cropping perspective, additional research is required in determining how to improve nitrogen utilization considering timing, placement, use of cover crops and existing soil organic matter content, especially in horticultural crop production systems.

Part 2: Research is required to better understand, and manage through BMPs, the mechanisms of phosphorus movement in Ontario soil conditions, especially as phosphorus soil tests increase from continuous manure application. In addition, the crop availability of phosphorus from biosolids undergoing different treatments needs to be better understood.

The benefit of the above research would be that it would help to provide better prediction of nutrient application options in nutrient management planning for manure and biosolids. Research would also potentially help identify which (sometimes contradictory) BMP would be best under specific field/soil/farm conditions.

Manure Application Systems: Timing, Nutrient Loading and Tillage Interactions. - Field Crops Subcommittee

Current research in Ontario addresses many issues associated with manure application, however, some areas of research require much more work. The time of manure application and the availability of nutrients from the manure is not completely understood. Manure is applied on frozen ground. The fate of the nutrients from manure applied on frozen soils in the environment has not been fully studied. Manure is applied at all other times of the growing season and the fate of nutrients in that manure is often not known.

Another manure application issue is nutrient loading. In some instances manure is applied at extremely high rates over many years. How much manure can be reasonably applied without losses of nutrients from the field to the environment? How can we best keep those nutrients in the soil that the manure was applied to? These are questions for which we need answers.

Reducing tillage may reduce the potential for runoff of manure and nutrient losses from fields. Research with manure application in reduced tillage conditions should be conducted to determine the

optimum methods, rates and timing of applied manure in reduced tillage systems.

Cover Crops and Nutrient Cycling for Absorption of Manure Nutrients. - Field Crops Subcommittee

There is a need for research to determine the effectiveness of cover crops for nutrient absorption and retention in fields that receive manure. Research can also be conducted to determine the rate that nutrients are released from the cover crops for subsequent crops. The research should include the optimum types of cover crops for application of manure at different times of the growing season and different types of manure. This research is needed to improve nutrient management planning.

Impacts of Organic Wastes and Biosolids on Horticultural Crop Production - Horticultural Crop Subcommittee

There is ongoing interest in using various waste organic amendments in the horticulture industry by both the waste handlers and growers. Continued research is required to determine the effectiveness and adaptability of these amendments to horticultural production. It is also necessary to determine the effects of potential detrimental products in these amendments such as heavy metals, salts or other chemicals.

Integration of Research Results into the Development of Information Systems and Decision Tools for Nutrient Management. - Waste Utilization Subcommittee

Every farmer using nutrients will require a nutrient management plan within the next decade. Nutrient management issues have and are resulting in more and diversified research into all aspects of nutrient use as well as potential environmental losses. Tracking farm nutrient data using land base management tools and computerized GIS systems are components being incorporated into nutrient management planning. The end goal is an effective, relatively simple and economic document.

As research is completed in various areas of nutrient management, there is a need to integrate and verify the research and field results using software models (such as M-Clone).

Benefits include increased confidence that all factors researched independently will, when combined, result in nutrient management plans that are “doable” and will have the intended or desired effect from an environmental protection perspective.

Development of a Method to Conduct and Present Scientific Research to the Public - Waste Utilization Subcommittee

Manure and biosolids and their production and application have created many conflicts within neighbourhoods and communities. If the smell would disappear, the issue would be largely reduced. Concerns around ground water study results, recharge areas, pathogen contamination to name a few, have resulted in municipalities creating bylaws to stop or slow down large livestock operations and/or the application of biosolids. When emotions run high around “a nutrient management issue” there is nothing to be gained by the “public” in being reasonable about science when trying to fight against the issue. At the same time it is not “the public’s” responsibility to find the solutions.

Consideration must be given to how scientific studies are conducted and reported so that “the public” has the “education” to make an informed decision.

The benefit of more reasonable debate over issues around nutrient management would improve understanding and relations between large livestock (and small livestock) operations and their non-farm, rural neighbours.

Predicting N availability from manure - Soil Test Lab Subcommittee

Develop methods to improve the prediction of nitrogen availability from manure. Specific topics to address include:

1. Impact of sample handling, storage and preparation on analytical results.

2. Assessment of the proportion of ammoniacal N in manure samples that is volatile.
3. Improved prediction of the availability of N from the organic fraction.

Predicting P availability from manure and biosolids - Soil Test Lab Subcommittee

Assess the phosphorus availability from manure and biosolids, and develop improved methods for predicting this availability, if necessary.

Standard methods for manure analysis - Soil Test Lab Subcommittee

Develop Standard Methods for manure analysis (Total N, P, K, NH₄-N, Dry Matter). This would be accomplished in stages: First, survey labs for methods currently being used, and assessing differences and similarities. Second, complete a literature review to assess appropriateness of current methods. Third, exchange samples among labs to compare results from different labs.

4. Recommendation 4: Manure and Biosolid Treatment

Research investigating management methods for organic soil amendments that control odours, kill pathogens, and reduce nutrient loss.

Animal manures and biosolids represent a valuable source of nutrients for agricultural crop production as well as a source of organic matter. They are known to improve soil physical, chemical, and biological characteristics and have the potential to enhance crop yields. At the same time, public health and environmental concerns regarding objectionable odours, chemical contaminants and pathogens present a challenge for the storage and safe handling of animal wastes and biosolids. Concentrations of nutrients in these materials vary both over time and among treatments and storage methods. Increased public concern over the odours, potential transmission of pathogens and nutrients into surface and ground water as well as into the food chain has generated interest in the use of manures and biosolids which have been subjected to some form of treatment to reduce these problems. There is a need to investigate the effect of different management methods and treatments for these organic amendments on the control of odours, reducing the number of potential pathogens and maintaining their nutrient content for the production of agricultural crops grown in Ontario.

Specific recommendations:

Effect on Nutrient Availability, Pathogen Reduction, Greenhouse Gas Emissions and Economics of Various Treatment Systems for Liquid and Solid Manure and Biosolids. - Waste Utilization Subcommittee

Manure and Biosolids are under increasing scrutiny from society due to potential nutrient contamination and pathogen contamination of water sources. Increasing

interest in alternative manure treatment systems is a result of increased public pressure combined with large liquid volumes and limited land base (in some areas of Ontario) for more manure/biosolid application. Liquid systems including anaerobic digesters, aerobic systems, electrolysis of manure are being discussed and tried to evaluate pathogen, odour and nitrogen reduction potential. Solid systems including proper composting, sterilization and complete drying of manure is also being evaluated for odour, volume and pathogen reduction. From a mechanical point of view these systems can work.

Research is required to determine the effect of treatment systems on nutrient content and availability, pathogen reduction, as well as on various greenhouse gas emissions. Although not as critical, the economics of these systems must also be considered (for example what is the cost of treatment versus the improvement in pathogen/nutrient/lack of greenhouse gas emissions). The economics play an important role in determining how economic instruments can be designed to evaluate the benefits (ie how much society could/should pay).

This research would benefit both livestock producers and rural landowners. Livestock producers with large liquid manure systems, especially in areas where land base is limited could reduce land base requirements for manure application. Manure/biosolid applicators and rural landowners would have decreased risk from nutrient and pathogen contamination as well as reduced odours. A by-product of some treatment processes could also lead to the development of “green energy”.

Impact of manure treatment strategies on odours, pathogens and nutrients. - Soil and Water Quality Subcommittee

This research would include various methods of manure treatment including composting and methane digesters. The goal would be to control odours, kill pathogens and reduce losses of nutrients from manures.

Recommendation 5: Soil Management and Soil Quality

Research leading to determining the effects of soil management practices on chemical, biological and physical soil quality.

Soil is a critically important element of sustainable agricultural production, functioning not only in food and fibre production but also in maintaining local, regional and global environmental quality. High quality soils will not only be more productive but will also play a major role in enhancing air and water quality. Past soil management for food and fibre production has taxed the resiliency of natural processes to maintain a balance of the cycling of energy and matter. Degradation of the soils productive capacity has occurred as a result of intensive agricultural production and resulting soil erosion, atmospheric pollution, cultivation and land clearing. Water quality is jeopardized by our choice in soil management and the consequent imbalance of C and N cycling in the soil. The present threat of global climate change and soil management issues dealing with carbon sequestration and the reduction of greenhouse gas

emissions, warrants a better understanding of the effects of soil management on soil processes. As such, soil management practices, such as tillage, cropping pattern, and fertilization influence soil, water, and air quality. Assessing soil quality and its impacts on productivity and the environment is complicated since research must consider the multiple functions of soil and integrate the physical, chemical and biological soil attributes that define soil function. However, to achieve the goals of high crop yields and quality with minimal environmental impact requires reliable research information that assesses the impact of management on soil quality and on soil use. In addition, the fundamental requirements of profitability and competitiveness must be incorporated into the overall soil management strategy.

Specific Commodity / Discipline Based Priorities:

Management impacts on soil physical quality - Soil and Water Quality Subcommittee

Research into how management factors such as crop rotation, tillage, soil compaction, and fertilization affect soil quality factors such as soil strength, structure, bulk density, water storage and transmission is required. Support for maintaining long term plots is essential to complete this research.

Compaction Reduction and Amelioration - Field Crops Subcommittee

Research should be conducted into methods of reducing and avoiding compaction, which are suited to Ontario equipment and circumstances. Current recommendations are good for compaction avoidance, however, we need more research on ameliorating compaction already present.

Effects of Cover Crops in Horticultural Crop Systems on Soil Quality - Horticultural Crops Subcommittee

Cover crops are still minimally utilized in fruit and vegetable production in Ontario. Research is needed to determine the best systems to incorporate cover crops into annual vegetable production systems and to determine the best sequences of crops in these systems. Also, ongoing trials and research are necessary to compare cover crops and organic amendments and their effects on soil nematode populations.

Optimizing Soybean Production Under Shorter Soybean Rotations. - Field Crops Subcommittee

Farmers in the province are growing soybeans in very short rotations (if they use rotations at all). Studies to determine how to best maintain yields of soybeans should be conducted. The length of soybean rotations for preventing the buildup of pathogens such as rhizoctonia root rot and soybean cyst nematodes should be studied. The effects of soybean based rotations on soil structure and other properties could also be included.

Much work was done with corn and many of the problems that were studied for corn must be studied for soybeans as well.

Impacts of Alternative Crop Rotations on Tobacco yield and Quality – Tobacco Subcommittee

Preliminary tests conducted in Ontario have shown that some pearl millet cultivars can suppress root-lesion nematode (*Pratylenchus penetrans*) populations to levels that are comparable to those achieved with chemical fumigation. These tests have led to the consideration that pearl millet can be grown by tobacco farmers as an alternative cover crop. However, additional tests are needed to determine (a) the effectiveness of selected pearl millet cultivars for nematode control and (b) the effects of pearl millet rotation on yield and quality of the subsequent tobacco crop.

Specifics: i) Determine the effects of organic matter sources, particularly, sorghum, millet, and manure, on agronomic performance and leaf chemistry levels. ii) Determine if root-lesion nematodes can be controlled and pesticide use reduced through certain crop rotations.

Tillage Impacts on Tobacco Quality and Yield - Tobacco Subcommittee

There is some interest in conservation tillage practices for tobacco production in Ontario. The advantages of minimum tillage include reduced soil erosion and increased water use efficiency. This work will determine the management practices feasible for no-till cultivation of flue-cured tobacco in Ontario.

Impacts of Reduced Tillage in the Horticultural Industry. - Horticultural Crops Subcommittee

There has been little adoption of reduced tillage systems for fruit and vegetable production. Research is still needed to identify the level of tillage reduction and the effect of plant residue on vegetable yields for Ontario conditions and soils.

Corn Cropping Systems. - Field Crops Subcommittee

Much work has been done involving crop production systems with corn. However, some areas still require more work. The planting of no-till corn after winter wheat requires more study. Farmers have identified reduced emergence and plant stands and reduced yields related to growing no-till corn after winter wheat. Research to investigate residue management after winter wheat should continue.

Methods of coping with the increased residue on the soil surface and cooler moister seedbed conditions must be developed.

The use and benefits of cover crops in corn cropping systems could be addressed.

Lime issues related to no-till corn production should be addressed as well. Lime is relatively insoluble and immobile in the soil. In no-till production when the option of incorporating lime with tillage is no longer available, the efficacy of lime additions is not well documented.

Service Recommendations

1. A task force should be established to increase the emphasis on development of an integrated system for N management for crops, to build on the current effort. The task force should include expertise in the sciences of agrometeorology, soil physics and hydrology, soil chemistry and crop management. - Field Crops Subcommittee

Action: Referred to Bill Ingratta, OMAF

1. The Agronomy Guide should be made available on the OMAF Web Site on the Internet - Field Crops Subcommittee

Action: Referred to John Findlay, OMAF

1. A letter should be sent to Dr. M.J. Goss, Director Agri-Food System Resources & Environment Research Program, outlining the concerns of the Horticulture Crops Subcommittee regarding the lack of current research and funding in the area of nutrient management for horticultural crops. The letter should emphasize the importance of this issue and its support by OSMRSC. - Horticulture Crops Subcommittee

Action: Letter sent to M.J. Goss.

1. OMAF tobacco extension should provide growers with one-on-one consultation when required. - Tobacco Subcommittee

Action: Referred back to tobacco subcommittee for their direct action.

1. Full-time administrative support is needed for the tobacco extension specialists in order to allow them to focus on their primary duties of technology transfer, problem identification and grower education. The extension office should be staffed during regular business hours to ensure that growers have full access to extension services. - Tobacco Subcommittee

Action: Referred back to tobacco subcommittee for their direct action.

1. More production information related to tobacco should be on the OMAF web site, i.e. fertility management practices for producing seedlings in dry trays. - Tobacco Subcommittee

Action: Referred back to tobacco subcommittee for their direct action.

1. OMAF should prepare an information package on best management practices for raising seedlings in float trays.

Action: Referred back to tobacco subcommittee for their direct action.

1. Standardization of Manure and Biosolid Analysis Procedure and Reporting of Results - Waste Utilization Subcommittee

Background: Ontario labs accredited for Ontario Soil Testing have shared and used the same methodology for manure sampling. Biosolids analysis uses different methodology

that makes “apples to apples” comparison difficult. For example, total elemental P is analyzed but how does this relate to available phosphorus?

Recommendation: A standard procedure is required for both manure and biosolids and other land -applied organic materials analysis and reporting so that results are comparable.

Benefits will include a consistent approach that will allow an easier understanding of nutrient values for nutrient applicators, for livestock producers and for the crop producers receiving land-applied organic materials.

Action: Referred to standards development group for Bill 81 (Sharon Johnson, OMAF).

1. Increase in Public Awareness of the Benefits of Biosolids as a Method to Increase Acceptance and Use of Biosolids for Land Application. - Waste Utilization Subcommittee

Background: Biosolids make up a large portion of land applied materials in Ontario, and will increase in the future. Municipalities are looking for opportunities to land apply the materials. Public acceptance of biosolids is low, and among farmers there is a reluctance to accept biosolids on farms due to uncertainties about potential contaminants of the material. It is recommended that to improve public awareness of biosolids a quality standard approach such as an ISO 14000 designation should be implemented. Such a system, though expensive to implement, would increase public and user confidence in land-applied biosolids.

Action: Letter of support for certification of biosolids applicators to be sent to WEAO.

1. Databases & data repositories.

Existing data from soil and water quality experiments should be centralized in databases which would be accessible to researchers to integrate new research into existing research and allow an upgrade of recommendations as warranted. This would not be a listing of experiments, but contain the actual data and results. Ideally the databases would be web based and be able to be sorted by factors such as country, soil type and date of research. - Soil and Water Quality Subcommittee

Action: This issue deals with intellectual property rights and is referred to OSWARSC for further action.

1. Soil Surveys

Soil surveys in Ontario should be upgraded and redone to improve decision making by Ontario citizens. There are gaps in the soil survey information of the province which should be filled. For example, there is no known copy of the Brant County report. Other reports are dated and/or were produced at larger scales or under different classification systems. - Soil and Water Quality Subcommittee

Action: Soils Ontario, a subgroup of Land Information Ontario, with involvement of OMAF, MNR, MOEE and AAFC, are starting to on digitizing soil maps and other geographic information. Further action should be taken by OSWARSC to upgrade soil information systems.

1. Precision Agriculture:

Existing information dealing with precision agriculture should be available to farmers requiring this information through factsheets.- Soil and Water Quality Subcommittee

Action: Referred to OMAF Publication committee.

1. Manure Management Information

Existing information concerning manure management should be extended to the public as efficiently as possible. Demonstration of Best Management Practices is needed to promote the most effective means of managing manure. - Soil and Water Quality Subcommittee

Action: Letter written to OMAF, University of Guelph and AAFC.

1. Soil Management and Soil Quality

An effort should be made to increase the awareness of the importance of soil quality in crop production. Information sessions, such as the soil quality workshop as well as displays at the Ontario Farm Show should be continued. The Soil and Water quality committee encourages OMAF to complete the Buffer Strip Best Management Practices Publication and the Soil Management compact disc. - Soil and Water Quality Subcommittee

Action: Referred to OMAF Publications Committee.

1. Factsheets on N Index and Manure Application.

The Soil and Water Quality Subcommittee recommends that OMAF produce factsheets on manure management and the N Index. - Soil and Water Quality Subcommittee

Action: Referred to OMAF Publications Committee.

OSMRSC Membership List

Dr. R. Beyaert (Chair)
Agriculture & Agri-Food Canada
Research Centre
1391 Sandford Street,
London, ON N5V 4T3

Tel: 519-457-1470 x.281
Fax: 519-457-3997
E-mail: beyaertr@agr.gc.ca

Mr. Adam Hayes (Vice Chair)
Crop Technology, OMAF
Ridgetown College of Ag. Technology
Ridgetown, ON N0P 2C0

Tel: 519-674-1621
Fax: 519-674-1600
E-mail: adam.hayes@omaf.gov.on.ca

Dr. Ivan O'Halloran (Past Chair)
Ridgetown College of Ag. Technology
Ridgetown, ON N0P 2C0

Tel: 519-674-1635
Fax: 519-674-1600
E-mail: IOHallo@ridgetownc.uoguelph.ca

Mr. Keith Reid (Secretary)
Soil Fertility Specialist, OMAF
581 Huron St.
Stratford, ON N5A 5T8

Tel: 519-271-9269
Fax: 519-273-5278
E-mail: keith.reid@omaf.gov.on.ca

Dr. Craig Drury
Agriculture & Agri-Food Canada
Greenhouse & Processing Crops Research Centre
2585 County Rd. 20
Harrow, ON N0R 1G0

Tel: 519-738-2251 x.473
Fax: 519-738-2929
E-mail: druryc@agr.gc.ca

Mr. John Rowsell
New Liskeard Agric. Res. Station
Box G
New Liskeard, ON P0J 1P0

Tel: 705-647-8525 x. 221
Fax: 705-647-7008
E-mail: jrowsell@onlink.net

Dr. David Kroetsch
Agriculture & Agri-Food Canada
Central Exp. Farm
Ottawa, ON K1A 0C6

Tel: 613-759-1892
Fax: 613-759-1937
E-mail: kroetsch@agr.gc.ca

Mr. Godfreid Amankwa (Chair, Tobacco
Subcommittee)
Canadian Tobacco Research Foundation,
P.O. Box 1
Delhi, Ontario N4B 2W8

Tel: 519-582-1950 x.282
Fax: 519-582-3678
E-mail: gamankwa@ontarioflue-cured.com

Ms. Maria Derkacz
Horticultural Experiment Station
Box 7000
Vineland Station, ON L0R 2E0

Tel: 905-562-4141 x.137
Fax: 905-562-3413
E-mail: mderkacz@hrio.uoguelph.ca

Pat Feryn
(Chair Soil and Water Quality Subcommittee)
R.R.#2 Stratford, ON N5A 6S3

Tel: 519-272-4434
Fax: 519-272-1404
E-mail: pferyn@cyg.net

Mr. W.E. Curnoe
Kemptville College of Ag. Technology
Kemptville, ON K0G 1J0

Tel: 613-258-8336 X.333
Fax: 613-258-8477
E-mail: bcurnoe@kemptvillec.uoguelph.ca

Mr. R. Stone
OMAF
Box 8200, 95 Dundas St.
Brighton, ON K0K 1H0

Tel: 613-475-1630
Fax: 613-475-3835
E-mail: bob.stone@omaf.gov.on.ca

Mr. Christoph Kessel

Tel: 519-824-4120 X.2480

(Chair Horticulture Crops Subcommittee)
OMAF, Department of Land Resource Science
University of Guelph
Guelph, ON N1G 2W1

Fax: 519-824-5730
E-mail: christoph.kessel@omaf.gov.on.ca

Ms. Anne Verhallen
Crop Tech. Hort.
OMAF, Box 400
Ridgetown, ON N0P 2C0

Tel: 519-674-1614
Fax: 519-674-1600
E-mail: anne.verhallen@omaf.gov.on.ca

Dr. Tom Bruulsema
Potash & Phosphate Inst. Of Canada
18 Maplewood Dr.
Guelph, ON N1G 1L8

Tel: 519-821-5519
Fax: 519-821-6302
E-mail: bruulsem@ppi-far.com

Mr. Doug Young
(Chair Field Crops Subcommittee)
Ridgetown College of Ag. Technology
Ridgetown, ON N0P 2C0

Tel: 519-674-1631
Fax: 519-674-1600
E-mail: dyoung@ridgetownc.uoguelph.ca

Mr. Brent Kennedy
Crop Technology, OMAF
1 Stone Road West
Guelph, ON N1H 6N1

Tel: 519-826-3257
Fax: 519-826-3567
E-mail: brent.kennedy@omaf.gov.on.ca

Mr. Marius Marsh
Ministry of Environment
2nd Floor, 40 St. Claire Ave. W.
Toronto, ON M4V 1M2

Tel: 416-212-1523
Fax: 416-327-6421
E-mail: marius.marsh@ene.gov.on.ca

Mr. Sid Ryzebol
Ont. Soil & Crop Imp. Association
R.R. #7
Orangeville, ON L9W 2Z3

Tel: 519-941-2914
Fax: 519-941-5592
E-mail: s.t.p.ryzebol@sympatico.ca

Dr. John Lauzon
Department of Land Resource Science
University of Guelph
Guelph, ON N1G 2W1

Tel: 519-824-4120 x.2459
Fax: 519-824-5730
E-mail: jlauzon@lrs.uoguelph.ca

Mr. Alvin Topp
Ont. Soil & Crop Imp. Association (alternate)

Tel: 905 774-8380
Fax: 905 741-8380
E-mail: johndeere@linetap.com

Mr. Ian McLachlin
(Chair Ontario Soils Lab Subcommittee)
A & L Laboratories East, Inc.
2136 Jetstream Rd.
London, ON N5V 3P5

Tel: 519-457-2575
Fax: 519-457-2664
E-mail: mclachlin@al-labs-can.com

Ms. Christine Brown
(Chair Waste Utilization Subcommittee)
OMAF, P.O.Box 666
Woodstock, ON N4S 7Z5

Tel: 519-537-8305
Fax: 519-537-5351
E-mail: christine.brown@omaf.gov.on.ca

Ontario Water Management Research & Services Committee

Ontario Water Management Research & Services Committee

Annual Meeting: Sept. 24, 2002.

Present:

Chris Attema, Livestock Commodities Group
Ted Briggs, Upper Thames R. Conservation Authority
Laurie Minshall, Grand River Conservation Authority
Debbie Brander, Dairy Farmers of Ontario
Mary Jane Conboy, Ontario Federation of Agriculture
Stewart Sweeney, OMAF
Paul Brine, OMAF
Paul Sibley: Environmental Biology, University of Guelph.
Ramesh Rudra, Engineering, University of Guelph
Mike Goss, Land Resource Science, University of Guelph.
Gary Parkin, Land Resource Science, University of Guelph.

Regrets:

Elbert van Donkersgoed, Christian Farmers Federation
Sam Bradshaw, Ontario Pork
Jon Gingerich, Cold Spring Farms
Dan Reynolds, Agriculture and Agri-Food Canada
Ed Topp, Agriculture and Agri-Food Canada.
Hugh Simpson, OMAF

Meeting Agenda:

1. Introductions, 2. Review of 2001 Report, 3. Current Issues\Outline of Report

Current Water Management Issues and Recommendations

The emerging water management research and service issues are given below. Research issues are presented first with recommendations and suggested research topics summarized after each issue.

Research Issue A : Source Protection for Water Quality

Recommendation 1: Best Management Practices Economic and Environmental Cost-Benefit Analysis

Rural water quality “Best Management Practices”, including alternative livestock manure storage, nutrient management plans, partial, seasonal and complete livestock access restriction, innovative rural septic beds, urban stormwater runoff controls, riparian buffer strips, vegetative filter strips, wetlands and other practices all vary in terms of cost and the anticipated water quality benefit.

A thorough assessment of anticipated benefit and cost would provide some guidance in prioritizing activities for the source protection plans proposed in the Walkerton Report. The end product should be an analysis of options based on \$/kg phosphorus or \$/E.coli bacteria.

Suggested Research Topics:

- testing of BMPs for liquid and solid manure application timing and methods in terms of pathogen and nutrient fate.
- investigate alternatives to land application of manure and condensing of liquid manure such as use of organic bedding material and composting.

- pilot-scale testing of new methods of managing\utilizing liquid manure such as composting, condensing, pre-treatments, energy from manure (eg. methane digestion).
- evaluate the effectiveness of different types of injection/incorporation equipment and new controlled rate application technologies (flow meters with injection booms) vs. current methods.
- leaching losses of feed supplements such as growth hormones, antibiotics, micro-nutrients, heavy metals.
- how to reconcile no-till crop production systems with recent recommendations to pre-till prior to manure application.

Recommendation 2: Establish a Watershed Nutrient Loading Capacity and Identify Sources of Contamination.

Policy should be established that outlines the total nutrient loading capacity of a watershed. If the loading capacity is exceeded then the amount of reduction necessary to achieve appropriate levels must be quantified. This policy would assist municipalities in developing a consistent and fair mechanism to assist with land use decisions.

Suggested Research Topics:

- identify surface water stress indicators related to excess nutrient load.
- identification of transport pathways of bacteria and other pathogens to groundwater.
- benchmark standards for tile water quality.
- identification of transport pathways of NPK fertilizers and pesticides.
- scale of farming operation versus amount of leaching and runoff losses of pathogens and nutrients.
- Is DNA Fingerprinting of source contaminates a reliable method to identify the source of contamination?

Recommendation 3: Establish Guidelines for Site Investigations and Continued Monitoring of Proposed Intensive Farming Operations and Biosolids Application.

Current guidelines for investigating potential contamination of groundwater and surface water from existing and proposed farming operations have not been firmly established. Approved methods and levels of intensity of investigations need to be developed. This information would provide farmers, municipalities, Provincial government bodies, etc. with tools to determine consistent and fair approaches for site investigations.

Suggested Research Topics:

- determine most cost-effective method to assess impacts of large-scale farming operations and biosolids application, investigate use of non-intrusive methods of soil and groundwater characterization; if monitoring wells are required, how many to install?; are existing databases adequate to determine potential impacts?
- determine minimum frequency of groundwater and surface water samplings required to monitor large-scale farming operations and biosolids application.

Recommendation 4: Municipal Well Head Protection and Groundwater Vulnerability Criteria.

Municipalities across Ontario are compiling wellhead protection and groundwater vulnerability maps based on characteristics such as depth to bedrock, physiography, depth to water table, extent of aquifers and recharge rates. Designation of protected and vulnerable groundwater areas may have a significant impact on crop management and livestock agriculture.

Suggested Research Topics:

- develop criteria based on sound scientific and risk management principles to designate sensitive and vulnerable areas.
- rural development strategies to limit the number of new water wells and promote the use of innovative septic systems.
- develop fair land use designation tools.

Research Issue B: Source Protection for Water Quantity

Recommendation 5: Establish a Sustainable Water Extraction and Sharing Policy and Monitoring System to Ensure Future Supplies are Protected.

The quantity of groundwater and surface water supplies could be at risk in the future, especially if growth continues at the current rate and climatic changes bring more dry years. A sustainable water extraction policy and an adequate monitoring system are required to ensure that future supplies are available. The policy would assist planners in resolving issues in water use/overuse conflicts and could be used as a decision-making tool when assessing applications to take water.

Suggested Research Topics:

- should surface water or groundwater be the main sources of potable water?
- irrigation management for water conservation and reduction of leaching losses of fertilizer and pesticide, affordable alternative irrigation methods..
- defining water needs of the natural environment.

Recommendation 6: Quantify Current and Future Farm- and Watershed-Scale Hydrologic Water Cycles.

The water budget of a farm divides the received precipitation into four basic components: evapotranspiration, runoff, drainage, and soil storage. The amount of water that each component accounts for impacts not only water quantity but also water quality issues. There is a lack of information available for different regions of Ontario on how water is partitioned into the four basic components given above. This information could assist farmers, planners, etc. in resolving current and future land use issues, site investigations for contaminant source identification, and resolving conflicts in water sharing.

Suggested Research Topics:

- determine the potential impacts of climate change on water surplus and deficits in the future for different regions in Ontario using computer simulation models.
- quantify water pathways including runoff, tile drainage, deep drainage, and evapotranspiration, particularly in winter season.
- how to scale-up from field to farm to watershed.

Service Issue A. Database for Water Management.

- design and maintain a web-based database for hydrological information and data required to run computer models of water flow and contaminant transport in Ontario.

Service Issue B. Database for Current and Past Groundwater and Surface Water Quality and Quantity.

- design and maintain a web-based database that would have information on current and past groundwater and surface water quality and quantity in Ontario.
- baseline monitoring of groundwater and surface water quality and quantity in Ontario with data available on the web site described above.

Summary of Current Research Conducted by Committee Members and their Affiliated Organizations and Areas Suggested for Further Study

1. Livestock Commodities Group (submitted by Chris Attema)

Manure Management Technology Evaluation

Livestock manure benefits include the N, P, K and micronutrient value, the slow release organic nitrogen form, and organic carbon for soil microbes improving soil structure. Manure application disadvantages include odour, pathogens, and soil compaction due to the mass and volume of applied material.

The Advance Manure Management Technologies for Ontario (AMMTO) project was initiated to identify manure management technologies available worldwide that may have potential to protect or enhance livestock manure benefits while addressing environmental, economic and social needs in Ontario. Long term and sustained funding is required for AMMTO to meet objectives.

Vegetative Filters to Protect Streams in Areas With Manure Storage or Disposal

R.P. Rudra, School of Engineering
University of Guelph

This project will investigate and evaluate the performance of vegetative filters, under Ontario conditions, for protection of watercourses from runoff that has been contaminated from beef manure. From the experimental results a computer-based management tool will be developed for designing vegetative filter strips. The model will account for the hydrologic dynamics of contaminated runoff and the attenuation characteristics of vegetated filters. Microorganisms, including *Cryptosporidium parvum* and bacteria, and key nutrients will be considered.

2. Dairy Farmers of Ontario (submitted by Debbie Brander)

Water Quality Research

5. Current DFO/U of G Research

- DFO currently working on a research project with Dr. Mike Goss of Land Resource Science
- Looking at water quality (total coliform, fecal coliform, and other bacteria) on 172 dairy farms in eastern Ontario
- Initial benchmark study conducted (initial water results and survey data)
- Follow up on farms with E.coli or fecal coliform to investigate source of contamination and suggest potential solutions
- For farms with chronic issues or contamination source problems that cannot be resolved, wish to investigate most appropriate treatment systems

6. Areas for Further Study:

Determination of the efficacy and practicality of different water treatment systems on dairy farms.

This study should include cost-benefit analysis, maintenance and routine upkeep requirements, pre-treatment water requirements as well as overall efficacy of pathogen kill.

Ground and Surface Water Protection Research

Areas for Further Study

Re-visitation of “Best Management Practices” to ensure they are based on current science. In particular, determination of acceptable manure storage and run-off treatment systems including:

- vegetative filter strips for run-off control
- minimum standards for clay lined earthen manure storages

Communication of Research to Commodity Groups

There is need to develop an on-going reporting mechanism to industry including:

- Proposed projects awaiting funding through grants / industry
- Current projects – including brief synopsis of similar work done elsewhere

**3. Active Water Quality/Quantity Research Programs at the Greenhouse and Processing Crops Research Centre, Agriculture and Agri-Food Canada, Harrow, Ontario, 2002
(submitted by W.D. Reynolds and C.S. Tan)**

i. Development of “closed loop” water management systems to improve the efficiency of water and nutrient use in field-crop environments (C.S. Tan, C.F. Drury, W.D. Reynolds, T.Q. Zhang, J.D. Gaynor).

In a “closed loop” water management system, tile drainage water and surface runoff water from agricultural fields are routed into a closed reservoir, rather than into open-ended streams and drainage ditches. The collected water is then recycled back to the fields as surface or subsurface irrigation water during times of water deficit. The reservoir serves as a sink to prevent off-site movement (loss) of water and sediments, and also provides a means for intercepting and recycling agricultural nutrients and chemicals via return irrigation. As a result, precipitation water is used more efficiently, and the discharge of agricultural sediments and chemicals into off-site surface and ground water resources is reduced substantially. Over the last 2-3 growing seasons, we have found that runoff generated by occasional thunderstorms has been sufficient to maintain an adequate water supply in the reservoir for growing season irrigation. So far, the initial and ongoing economic loss associated with the conversion of part of the crop land to a reservoir has been more than offset by the increased crop yields on the remaining land through improved water and nutrient usage (via return irrigation), and by the environmental benefits associated with reduced off-site agrochemical and sediment contamination of water resources.

ii. Development of surface and subsurface drip irrigation and fertigation systems for field crops (C.S. Tan, T.Q. Zhang, W.D. Reynolds, C.F. Drury, A. Liptay).

Due to the increasing frequency of long periods of high temperatures and drought during the growing season, traditional gun and furrow irrigation systems are becoming less attractive to growers because of increased water costs and relatively high losses of water and/or nutrients to evaporation, surface runoff and deep drainage. Recent work at GPCRC has shown that surface and buried drip irrigation/fertigation systems substantially increase the efficiency of water and nutrient usage relative to traditional gun and furrow systems. Drip systems (especially buried systems) place a much greater percentage of water and nutrients within reach of crop roots. They also substantially reduce water losses by evaporation (because the water is applied on or below the soil surface), and by runoff and deep drainage (because the water is added slowly and the soil is not saturated). This year, preliminary trials on farm cooperator fields achieved substantial increases in processing tomato yields relative to non-irrigated crops, and the costs of installation and maintenance of subsurface drip lines appears to be economically viable.

iii. Use of amendments and conditioners to improve the water and nutrient storage characteristics of agricultural soils (W.D. Reynolds, C.S. Tan, C.F. Drury, T.Q. Zhang, X.M. Yang, T.W. Welacky).

Recent research at GPCRC indicates that the air capacity, plant-available water capacity and density in the crop root zone of fine-textured soils can be improved by adding conditioners, such as composts and greenhouse waste products. These improvements allow more efficient usage of

soil water and nutrients through improved functioning and growth of crop roots, which can in turn increase crop yields and reduce water and nutrient losses to surface and ground water resources. Work at GPCRC on a clay loam soil has found that compost applied at rates as large as 300 dry t/ha can produce near ideal bulk density, air capacity and plant available water capacity values without causing nitrogen immobilization.

iv. Controlled drainage and subsurface irrigation in the crop root zone (C.S. Tan, C.F. Drury, W.D. Reynolds, T.Q. Zhang, J.D. Gaynor, T.W. Welacky).

Traditional tile drainage systems are designed to rapidly remove excess water from the crop root zone to allow for more timely tillage, planting and harvesting with fewer negative impacts on the soil (e.g. compaction, smearing, etc.). Although these systems operate well for this purpose, the drainage water and any dissolved nutrients and pesticides cannot be recovered at a later date for use during water deficit periods. In addition, the drained water, nutrients and pesticides are usually channelled into surface water bodies (e.g. rivers, lakes) which may subsequently impair the quality of these water resources. It is possible, however, to manage the amount and rate of drainage from traditional tile systems by installing “risers” on the tile outlets. The risers increase the elevation of the tile outlet, and thereby effectively decrease the tile depth, which in turn retains more water and nutrients in the crop root zone. In addition, the risers can be removed for short periods in the spring and fall to facilitate planting and harvesting operations, and then re-installed to prevent excess drainage during the summer and winter periods. The risers can also be used to feed water back up the tile lines to provide efficient subsurface irrigation (and fertigation) of the crop root zone during water and nutrient deficit periods. Research at GPCRC has shown that controlled drainage with subsurface irrigation can produce large yield increases as well as substantial reductions in the loss of nitrate and pesticides in tile drainage water.

4. Water related studies undertaken by the Southern Crop Protection and Food Research Centre of AAFC and partners (submitted by E.Topp)

Research of the Field Crop, Soil and Environmental Quality Team at SCPFRC emphasizes contaminant fate, soil quality, and the development of farming systems which minimize environmental risk. The overall goal is to improve soil and environmental quality in the Great Lakes Basin by developing superior management practices that preserve and enhance land resources while maintaining economic benefits to society and minimizing risk to adjacent environments. Team members, subgoals, activities and publications can be viewed on our web site at <http://res2.agr.ca/london/pmrc/english/pmrchome.html>

Mitigation of contaminant transfer to the environment from fertilizer and manure by cover cropping, soil testing and appropriate rates and methods of application.

B. Ball Coelho, R. Roy (SCPFRC); Nuhn Industries, Green Lea Ag Centre, Da Costa Farms, Kevin Otto, Ontario Pork.

Transfer of nutrients to ground and surface waters following manure application can be minimized and crop nutrient utilization maximized by appropriate methods, timing and rates of application. Optimum timing for manure application to corn may be sidedressing because soil moisture content is usually lower and application rates can be determined more accurately than for fall or spring applications. In order to improve the prediction of manure sidedress rates based

on the pre-sidedress nitrate test (PSNT), corn yield response curves to sidedress liquid manure injection in relation to the PSNT, transfer of contaminants to drainage waters, and residual soil N are determined. Where liquid hog manure dry matter is high (>4%), sidedressing manure (with modified injection equipment) at rates which supply crop N requirements, does not contaminate tile drainage water.

Environmental persistence and impacts of endocrine-disrupting chemicals and antibiotics.

E. Topp, B. McGarvey (SCPFRC); M. Servos (Environment Canada); T. Ternes (ESWE, Germany).

Agriculture is accused of being a source of chemicals which interfere with the reproduction and development of wildlife. These so-called endocrine disrupting chemicals cause fish to produce offspring which are part male and part female, for example. Chemicals of concern include some pesticides and components of pesticide formulations, natural estrogenic hormones in some animal wastes, and synthetic organic compounds which can be carried by municipal biosolids applied to land. The persistence and breakdown of various natural (estradiol, estrone) and synthetic (ethynylestradiol, 4-nonylphenol) EDCs is being evaluated in field and laboratory studies. Laboratory microcosm studies indicate that all of these compounds are rapidly microbially degraded without production of estrogenic intermediates.

There have been recent concerns about the environmental impact of veterinary antibiotics, or antibiotic-resistant bacteria excreted by animals. We are conducting laboratory experiments examining the impacts of antibiotics on soil processes, and on the abundance of antibiotic-resistant bacteria. We are also evaluating soils fertilized with manure from medicated and non-medicated animals for differences in the abundance of antibiotic-resistant bacteria.

Enhancement of water use efficiency for crop production. R. Beyaert, B. Ball-Coelho, R. C. Roy, (SCPFRC); Ontario Processing Vegetable Growers, Robin Hood Multifoods Inc.

Surface and subsurface drip irrigation can increase water use efficiency by minimizing losses to evaporation, improving scheduling and increasing the capacity for control of internal drainage. Subsurface fertigation further provides opportunities to utilize nutrients more efficiently and improve water quality through better timing of application and placement of nutrients, and minimal water losses by deep percolation and erosion. Many advances in subsurface drip irrigation have been made in recent years, however, most of the work has been done in loam soils and little is known about how these systems behave under Ontario climatic conditions and coarse-textured soils. To develop advanced irrigation methods that improve water-use efficiency and minimize nitrate leaching, experiments were conducted to compare water use efficiencies and nitrate leaching of overhead, surface drip and sub-surface drip irrigation, and traditional dry broadcast fertilization with fertigation.

Ecology of indicator and pathogenic bacteria carried in livestock waste in soils and stored manures. E. Topp, B. Ball Coelho, K. Conn (SCPFRC); Ontario Pork.

Enterohemorrhagic *Escherichia coli* is the most important recently emerged group of food-borne pathogens. Human and livestock exposure to fecal pathogens via contaminated surface or groundwater is an important health concern. There have been frequent recent high profile closings of beaches due to coliform contamination, suspected but not proven to originate from livestock operations. Survival of fecal bacteria in soil and on crop surfaces is an important

element of the environmental and health risks of manure application. The focus of this study will be to characterize the microbial composition and survival of enteric bacteria (*Shigella*, *Salmonella*, *Yersinia*, *Campylobacter*), and antibiotic-resistant bacteria in manure under different storage conditions, and in soil following broadcast or injection application.

Science-based management practices for utilization of municipal biosolids in agriculture. E. Topp, B. Ball-Coelho, B. Roy (SCPFRC), D. Lapen (ECORC), M. Goss (U of Guelph), S. Springthorpe (U of Ottawa); OFA, OME, OMAF, Terratec, several municipalities. The public is concerned about health and environmental impacts of using sewage sludge as a fertilizer. We are initiating a 3-year study with as objectives: 1. Identify major factors, indicators, and management strategies determining the risk of off-site movement of pathogens and selected pharmaceuticals from a range of soils receiving dewatered or liquid biosolids. 2. Determine the soil persistence and mobility of pathogens and pharmaceuticals carried in biosolid and carried in livestock manures. 3. Elucidate the risk to water from pharmaceuticals that reach land via municipal biosolids. 4. Initiate development of a regional-scale water quality risk model incorporating existing regional data bases and findings from plot and field-scale studies. The model would be tailored for assessment of ground and surface water buffer zones, biosolid application BMP recommendations, risk of water contamination under a variety of existing and projected environmental/land-use situations, and land use planning. 5. In partnership with OMAF and OME, use this knowledge to recommend biosolid application BMPs, and recommend minimum (horizontal and vertical) separation distances to surface and ground water bodies and wells, and the development of buffer areas.

5. Research ideas for OSWARSC (submitted by P Sibley)

13) **Pharmaceuticals.** Transport, fate and effects of pharmaceuticals, especially antibiotics, in soil and aquatic environments.

Key questions:

- i What relative proportion of antibiotics spread in manure reach aquatic systems?
- iii What effects occur in soil and aquatic systems? Are there potential risks to soil and aquatic fauna?
- ii What is the environmental activity (fate and effects) of metabolites formed from parent compounds?
- iv What is the potential for antimicrobial resistance among microbial populations?
- v Are their significant impacts on microbial populations (independent of resistance) such as shifts in community structure and function (e.g., nitrification)

Ideally, this research would yield information that could be applied toward the development of best management practices the minimize the likelihood of antibiotics reaching the environment.

14) **Pathogenic contamination.** Walkerton has clearly raised the profile regarding the transport and fate of pathogens in aquatic systems. Research concerning the viability of, and transport pathways for, pathogens such as *Cryptosporidium* are still needed. Of interest is how

pathogenic contamination resulting from agricultural practices might change in the face of long-term environmental phenomena such as global warming.

15) **Biosolids application.** Evaluation of land application of biosolids, most notably those from human waste facilities. This is a hot topic at the moment, largely because there is inadequate information regarding whether current management practices are sufficient to minimize risks to the environment, and because there is a poor understanding of potential impacts (especially to aquatic systems).

16) **Ecosystem effects of genetically modified organisms.** At a recent workshop (2001), Environment Canada identified this area as a key target for future research. At present, there is virtually no information of potential effects and risks of GMO's to the environment. For example, there is nothing known about the potential effects of genetically engineered insecticidal residues on soil organisms or the transport and effects of such residues to aquatic systems. Issues related to the effect of GMO residues on soil biodiversity may also become a prominent topic in the future.

**ONTARIO AGROMETEOROLOGY RESEARCH
AND SERVICES COMMITTEE**

ONTARIO AGROMETEOROLOGY RESEARCH AND SERVICES COMMITTEE

Alan McKeown

Chair.

October 31 2002.

Similar to previous years, 2002 can be summed up as one of extremes in climate. Severe frosts on the Victoria day weekend created significant losses in the Horticultural industry in fruits and vegetables. Summer drought added to the problems with very little precipitation falling in some areas, and/or very poor distribution. Summer weather also impacted quality of crops. For instance, cauliflower growers had problems with poor quality due to heat for summer fresh market; and for processing, hot fall temperatures favoured Alternaria head rots, which was severe; and greatly delayed floral initiation in some cultivars. These have created significant problems for the processing cauliflower industry.

Committee activities 2002.

The committee met on June 14 2002 for a brainstorming session on Agrometeorological research needs, and developed 10 major Agrometeorological topics that require study. These are:

1. Gas flux studies.
2. Manure storage and spreading.
3. Risk (Probabilities) of extreme events, climate variability and the effects thereof.
4. Odours from farms.
5. Power turbines.
6. Management for greenhouse gas reduction.
7. Spray drift is a recurring issue (related to odours).
8. Air quality.
9. Pest management.
10. Greenhouse warming.

Full details of these topics may be found in the minutes of the meeting (Appendix 1).

The common Agrometeorology issue in all the above is the Greenhouse effect or Climate Change, identifying the science behind, and of course adapting to climate change. The effects of climate on production seem to have been ignored in recent years. One such aspect is the variability of climate on production and was raised in a paper presented at the ISHS congress in Toronto in 2002 by McKeown et al and submitted for publication in Acta Hort. The following is an excerpt from this paper. (see also the research results section below).

Yield of cole crops, rutabaga and potatoes were found to decrease with warmer average temperature, number of days > 30 ° C, and with fewer days with precipitation. Higher temperatures probably will increase heat related quality disorders and possibly reduce vitamin content. Studies in US states adjacent to

Ontario have shown high variability of yield of field crop yields from about 1885 to the early 1950's followed by a period of benign climate until the early 1970's followed by a significantly more variable climate (Andresen et al., 2001). This is, of course the period of time which most people use as "normal" climate and is the basis of the 1950 - 1980 climate normals. It appears the climate is normally more variable than this period in time. This is of course, the period of time of greatest Agricultural and technological advancements. Basing normal climatic expectations on this period is risky, notwithstanding the effects of the Greenhouse warming. A component of variability was identified as due to ENSO events for field crops (Phillips et al 1999) and vegetables (Park et al 2002). Interannual climate variability is one of the greatest risks farmers face either from direct effects or effects on pests, fertilizer efficacy, or price, hence the effect on a nations food supply. One climate change projection suggests about 48 hot days ($>30^{\circ}\text{C}$) in the London area as opposed to the 1951-1980 climate normals of about 9 (Wheaton, 1999). Based on our results, this may have significant results. Estimated changes in the agricultural system by Wheaton include: longer growing seasons, more frequent droughts and wet spells, more frequent and intense heat waves, fewer cold spells in winter, increased risk of soil erosion by wind and water, decreased snow cover, increasing demands and conflicts over water, decreased river flows and levels, northward expansion of weed, insect and disease ranges, increased disease and pest pressure, decreasing air and water quality. All of the possible outcomes will impact on agricultural production. While cultivars are selected for yield, disease resistance, visual quality, quality pertaining to human nutritional components is not usually taken into account. We believe this is of concern in relation greenhouse warming issues. High temperatures are regarded to result in less vitamin C content. Temperatures less than 20°C favour vitamin C, $10 - 15^{\circ}\text{C}$ favour B vitamins in green vegetables. Warm season tomatoes had higher B vitamins at $27 - 30^{\circ}\text{C}$ which indicates potential differences in vitamin responses and concentrations between cool and warm season vegetables. Thus, with the cool season crops at least, not only do higher temperatures have the potential to reduce growth, increase visual quality disorders but in addition have the potential to reduce vitamin C content. This aspect is of great consideration in human nutrition, and since Vitamin C has had little work in the English speaking countries (Mozafar, 1994), a better understanding of genetics, climate production practices on this important human nutrient is warranted.

Crop yield trends, along with rising temperatures, show decreased and more variable yields with warming temperatures. While not conclusive proof of greenhouse warming vs natural variation, it suggest that if this trend continues we can expect lower more variable yields impacting on supply, quality and pricing. Unless management systems, cultivars etc., are developed to take variability and heat, both for yield, visual and nutritional quality into account, highly variable, poorer yields and quality may result, Higher temperatures will place more demand for irrigation water and scheduling, work to develop cultivars

with more stable yield and nutrient content over widely varying climate conditions. Failure to understand and develop means to overcome effects of greenhouse warming and climate change will have severe impacts on food production and our ability to feed ourselves. Climate induced crop failures have had significant impacts humans throughout our history. It is false to assume that we are immune to such changes. We owe our existence to a few inches of topsoil and timely precipitation, and heat.

Committee membership is dropping with the loss of Environment Canada (again), people leaving positions, effects of disclosures on commercial activities (need for corporate secrecy, I had one call from a former member who will not attend government meetings or disclose what they are doing for this reason), etc.

This year is at least the third for myself as Chair and I have no intention of remaining in this position. Issues and recommendations are similar to previous years and can be easily recycled.

RESEARCH ACCOMPLISHMENTS

1. University of Guelph

DEPT. OF LAND RESOURCE SCIENCE

Current research activity in the Agrometeorology group within Land Resource Science at the University of Guelph is focussed on gas exchange with agricultural sources and sinks, enhancing our understanding of the fundamental processes involved in turbulent transport in the atmosphere, and weather influences on plant diseases.

The contributions of agriculture to increasing greenhouse gases” in the atmosphere are being investigated on several fronts. A long-term experiment which monitors nitrous oxide (N_2O) fluxes through all seasons is continuing at the Elora Research Station. There are two treatments - conventional farming practices and best management practices - replicated on 1 ha plots that are sufficiently large to give adequate fetch for micrometeorological flux measurements. The experiment is in its third season of a corn, beans, wheat rotation. Best practices include such things as altered tillage, use of cover crops and altered fertilization schedules. Other researchers are monitoring soil and groundwater responses to the treatments, particularly aspects of the nitrogen balance.

In addition to this study, we are monitoring all aspects of the water budget in conjunction with the soil physics group lead by Gary Parkin. This work includes long-term eddy covariance measurements of heat, water and CO_2 fluxes, along with complementary energy budget measurements. Part of this work has

included a comparison of two identical open-path eddy covariance units. Results show excellent agreement between the two units under a range of conditions, but the energy budget is consistently only closed to 80%. In connection with the nitrogen balance and ground level ozone chemistry, some research has also begun on measuring fluxes of NO and NO₂. Agricultural surfaces are thought mainly to be sources of NO and sinks for NO₂. Fluxes of NO₂ to leaves have been investigated in controlled laboratory conditions and fluxes of both NO and NO₂ have been investigated over grass surfaces, some with differing fertilizer regimes. We have become aware that these flux measurements may be compromised by the fast chemistry that occurs between ozone, oxides of nitrogen and volatile organic compounds in the atmosphere such that the flux measured above the crop may not be fully representative of the flux that actually occurred at the crop surface. We are engaging in some measurements and modelling this summer to assess the magnitude of this effect.

Methane emissions have been, or are being measured from several manure storage and treatment facilities. Candidate sites include a solid manure storage area, and liquid manure storage facilities for both cattle and pigs on the farms of cooperating growers. Emissions from manure composting have also been investigated. In addition, methane concentrations downwind from an animal barn are being monitored for comparison with a diffusion model. In addition, a separate project with Ray McBride is examining the possibility of methane and nitrous oxide transport through the aerenchyma or transpiration stream of hybrid poplars used as an alternative cover on decommissioned landfills.

Work to apply the Lagrangian in-canopy flux/gradient model developed at Guelph continues. Measurements will be made this summer at both the Elora Research Station and the Camp Borden tower site run by Environment Canada. Currently we are also investigating the possibility of a two-dimensional version of the model. In another application of the Lagrangian work, a PhD candidate, Adriana Furon, has recently presented results of a coupled transport-flux model to investigate the scaling up from leaf to canopy.

A study of varying-width shelterbelts is nearing completion. This work has used both wind tunnel and numerical simulations to examine optimal widths for reduction of turbulent kinetic energy downwind of vegetated strips, whether they are riparian zones, agricultural windbreaks or parts of forest cut-blocks. Studies are currently investigating a comparison of the eddy covariance and flux-gradient methods. This is significant work because eddy covariance is often considered the 'standard' or 'best' method, but we often can't use it for certain gases or experiments, and so many workers rely heavily on flux-gradient.

Eddy covariance measurements have become essential in studies relating to mass, energy or momentum exchange at the earth's surface. However, there remain several important questions about the technique, foremost being the

strong evidence that energy budgets calculated with eddy covariance measurements do not close. In addition there are uncertainties about the random errors in the flux measurements and the suitability of applying a point measurement like eddy covariance to an areal source. To contribute to these debates, two identical eddy covariance systems were run in several configurations over approximately a two-year period. The systems were set up side-by-side, on opposite sides of one tower and on separate towers in adjacent plots, under two different management practices. In the latter case the two towers were about a hundred metres apart. The systems showed excellent agreement when run side-by-side. There was no evidence of systematic differences in the measurements, as defined by the slope and intercept of orthogonal regressions of the measured fluxes. They also showed little random error, as defined by the correlation coefficient, which provides an estimate of the precision of the flux measurements. The error from the effect of tower wind shadow was significant but showed a consistent pattern as a function of wind direction. In the adjacent-plot set up, small differences in fluxes were detected, consistent with our expectations for the different management practices as well as with concurrent measurements. The energy budget was closed to 83% with no clear explanation presented for lack of closure.

Pressures to reduce pesticide use are mounting from both environmental and economic perspectives. A possible response to these pressures is more widespread use of weather information to schedule fungicide applications so that optimum timing produces optimum results with minimum possible chemical usage. The need for information on the duration of leaf wetness is a continuing barrier to more widespread use of weather-based disease management schemes because the deployment of specialized leaf wetness sensors at the farm level is not practical. The utility of an approach similar to that used to estimate evapotranspiration (ET) for a variety of crops is being investigated. In this approach a "reference" leaf wetness duration is calculated from standard weather station data (like a reference ET) and adjustments are made to this value when applying it to various crops (just as crop ET is obtained from reference ET using a "crop coefficient"). Investigation of the best method to determine the reference wetness duration is underway, and development of adjustments to fit various crops is part of a new research initiative with colleagues at some northeastern U.S. universities.

Effect of agricultural activities on the atmospheric environment. Research activities are focused in quantifying and understanding trace gas emissions from agriculture, in particular gases that enhance the atmosphere's greenhouse effect.

In the past four years research activity has been concentrated on two major topics: 1) emissions of nitrogen oxide gases from soils as affected by nitrogen

cycling and management practices, and 2) greenhouse gas (methane and nitrous oxide) emissions from stored animal manure.

Emissions of Nitrogen Oxide Gases from Soils. In the last 2 years expanded field experiments to included the broader aspect of nitrogen cycling, in order to study gaseous emissions within the context of farm nutrient management. This has lead to closer collaboration with colleagues in Soil Science within my department as well as at Agriculture and Agri-Food Canada and abroad. Grants from several sources (OMAF, AAFC, CFCAS, and Environment Canada), are currently being used to fund a field experiment for quantifying the effects of best management and conventional practices on nitrous oxide emissions, and nitrate leaching at the Elora Research Station. Nitrogen cycling in these contrasting management systems is being quantified through the use of N¹⁵ techniques. Supporting soil and plant data, gathered through this experiment will be used in a modelling approach by my research group, and will be made available for any interested researchers. The data set being collected is unique in the attempt to quantify gaseous and leaching N losses from contrasting management systems, while also studying the cycling through the soil-plant continuum. Preliminary results for the first 2 years of this experiment, show that nitrous oxide emissions can be reduced by ~50% through increased N fertilizer use efficiency, without compromising yields. Some of these results were presented at the Agric. For. Meteorology Meetings in Norfolk, VA, in spring 2002, and will be submitted for refereed publication before December 2002.

Earlier research on related topics (1. effect of fertilizer type on N oxide emissions, and 2. N leaching from turfgrass, while yielding valuable information on N losses to the environment, also led to coordination of our research activities at one experimental site.

Greenhouse Gas Emissions from Stored Animal Manure. In the last 4 years, an opportunity was identified for research on the magnitude of greenhouse gas emissions from stored animal manure. Through collaboration with Prof. George Thurtell (now retired), we developed a novel method for measuring these gaseous emissions *in situ* with minimal disturbance of environmental conditions. This allows for year-round monitoring of emissions, which then will lead to an opportunity to understand the driving factors in temporal variability in emissions. Initial results have been published (publications # 9 and 14), and an AAFC funded project for measurement of emissions on commercial farms is currently under way. With funding from this and other projects (OMAF and Environment Canada), the research group has setup a mobile trailer housing our analytical instruments, which we are able to move between various locations for measurements. Recently, other members from our department (Prof. McBride and Warland) have benefited from this setup by using the mobile unit for monitoring of greenhouse gas emissions from a landfill site.

In addition to quantification of emissions from stored animal manure, work to identify mitigation practices for reduction of greenhouse gas emissions from manure. To this end, collaboration with Ron Fleming (Ridgetown College) in measuring emissions of greenhouse gases during composting of liquid swine manure (submitted publication #1). We have shown that composting can reduce greenhouse gas emissions by ~50%, however, only under optimal conditions of aeration. There is a large potential for additional research in this area since most proposed solutions for manure management have not been evaluated as for their effect on greenhouse gas emissions.

Results from this and other project are being integrated with results from colleagues in Animal and Poultry Science, School of Engineering and Agric. Economics.

Plant Agriculture

Climate change and vegetable crops.

There has been much discussion on the implication of climate warming on many factors, including food production. Climate models can be used to predict the effect of global warming, but is there evidence in yield data to suggest an effect of climate change? Cool season vegetables could be good indicators of changes, since they can be adversely affected by temperature extremes compared to some warm season crops such as corn. Thus, effects from climate warming may develop first in these crops. The average yield per hectare for several cool season vegetables in Ontario, including broccoli, cabbage and cauliflower, carrots, onions, and potatoes was examined over the past 60 years. Overall, yields increased from the 1940's until the mid-1980's. After this time, yields per hectare have decreased and appear more variable in spite of modern cultivars and production practices. Yield of field tomatoes has increased. Coincidentally, this has been the period of noticeably warmer climate. Are these changes in provincial yield data related to climate warming? Records in southern Ontario indicate a general increase in average air temperatures. Yield of cole crops, rutabaga and potatoes were found to decrease with warmer average temperature, number of days > 30 ° C, and with fewer days with precipitation. Higher temperatures probably will increase heat related quality disorders and possibly reduce vitamin content. Part of the decrease in yield might be a result of other factors, such as drought, soil compaction, or changes in the levels of insects and diseases. However, these would be expected to also change and interact, probably negatively, with climate warming.

SERVICES.

Ontario Weather Network: Ridgetown

On a positive note, things are looking somewhat better on weather stations. Environment Canada has taken over sites at Harrow, Delhi and Vineland. This will improve the data situation. There are not enough good monitoring sites in Ontario, and it was estimated that at least 330 sites are required. Data from many sites are obtained from shared data. There is some interest by the Ontario Climate Advisory Committee on data sharing. MNR is developing a land information database, a database of weather information could be useful. Of great concern remains the funding and maintenance of weather stations at the Muck station, Guelph, Simcoe, Ridgetown and associated uncertainties with OMAF. The Ontario weather network is refurbishing some stations and providing some weather related services on a fee for service basis. They also have data on a web site, but there is no base budget for anything.

PUBLICATIONS

Brown, H.A., **C. Wagner-Riddle**, and G.W. Thurtell. 2000. Nitrous oxide flux from solid dairy manure in storage as affected by water content and redox potential. *J. Env. Qual.* 29: 630-638.

Brown, H.A., C. Wagner-Riddle and G.W. Thurtell. 2002. Nitrous oxide flux from a solid dairy manure pile measured using a micrometeorological mass balance method. *Nutr. Cycl. Agroecos.* 62:53-60.

Burton, D.L., D.W. Bergstrom, J.A. Covert, C. Wagner-Riddle, and E.G. Beauchamp. 1997. Three methods to estimate N₂O fluxes as impacted by agricultural management. *Can. J. Soil Sci.* 77:125-134.

Edwards, G.C., G. W. Thurtell, G. E. Kidd, G. M. Dias, and C. Wagner-Riddle. 2002. A Diode Laser Based Gas Monitor Suitable for Measurement of Trace Gas Exchange Using Micrometeorological Techniques. *Agr. For. Meteorol.* (accepted January 2002, *in press*)

Groffman, P.M., R. Brumme, K. Butterbach-Bahl, K. E. Dobbie, A. R. Mosier, D. Ojima, H. Papen, W. J. Parton, K. A. Smith, C. Wagner-Riddle. 2000. Evaluating annual nitrous oxide fluxes at the ecosystem scale. *Global Biogeochem. Cycles* 14: 1061-1070.

Madiera, A-C., and T.J. Gillespie. 2001. A spectroradiometric approach to measure wetness on turfgrass. *Agric and Forest Meteorol.* 107: 117-130.

Maggiotto, S. R., J. Webb, C. Wagner-Riddle, and G.W. Thurtell. 2000. Nitrous and nitrogen oxide emissions from turfgrass fertilized with ammonium nitrate, urea and slow-release urea. *J. Environ. Qual.* 29: 621-630.

Maggiotto, S.R. and C. Wagner-Riddle. 2001. Winter and spring thaw measurements of N₂O, NO and NO_x fluxes using a micrometeorological method. *Water, Air and Soil Pollution: Focus* 1: 89-98.

McKeown, A. W., J. Warland and M. R. McDonald . 2002. Cool season crop production trends: a possible signal for global warming. Abstract XXVI International Horticultural Congress. P 289. (Abs).

Parkin, G.W. C. Wagner-Riddle, D. J. Fallow, and D.M. Brown. 2000. Estimated seasonal and annual water surplus in Ontario. *Can. Water Res. J.* 24: 277 - 292.

Roy, J. W., G. W. Parkin, and C. Wagner-Riddle. 2000. Timing of nitrate leaching from turfgrass after multiple fertilizer applications. *Water Quality Research J. of Canada* 35(4): 735-752.

Roy, J. W., G. W. Parkin, and C. Wagner-Riddle. 2000. Water flow in unsaturated soil below turfgrass: observations and LEACHM (within EXPRES) predictions. *Soil Sci. Soc. Am. J.* 64: 86-93.

Roy, J.W., J.C. Hall, G.W. Parkin, C. Wagner-Riddle and B.S. Clegg. 2001. Seasonal leaching and biodegradation of Dicamba in turfgrass. *J. Environm. Quality* 30: 1360-1370.

Taylor, N., C. Wagner-Riddle, G.W. Thurtell, and E.G. Beauchamp. 1999. Nitric oxide fluxes from an agricultural soil using a flux-gradient method. *J. Geophys. Res.* 104 (D10):12,213-12,220.

Wagner-Riddle, C., Edwards, G.C., and G.W. Thurtell. 2002. Trace Gas Concentration Measurements for Micrometeorological Flux Quantification, in *Micrometeorological Measurements*, ASA Monograph (accepted February 2002).

Wagner-Riddle, C., and G.W. Thurtell. 1998. Nitrous oxide emissions from agricultural fields during winter and spring thaw as affected by management practices. *Nutr. Cycl. Agroecos.* 52: 151-163.

Wagner-Riddle, C., T.J. Gillespie, L.A. Hunt, and C.J. Swanton. 1997. Modeling a rye cover crop and subsequent soybean yield. *Agron. J.* 89: 208-218.

Wagner-Riddle, C., G.W. Thurtell, G.E. Kidd, E.G. Beauchamp, and R. Sweetman. 1997. Estimates of nitrous oxide emissions from agricultural fields over 28 months. *Can. J. Soil Sci.* 77: 135-144.

Submitted

McKeown, A. W., J. Warland and M. R. McDonald . 2002. Cool season crop production trends: a possible signal for global warming. XXVI International Horticultural Congress. Submitted for publication in Acta Hort.

Thompson, A.G., C. Wagner-Riddle, and R. Fleming. 2002. Emissions of N_2O and CH_4 during the composting of liquid swine manure. Env. Monitoring and Assessment (submitted July 17, 2002)

Papers Read at Conferences

Brown, H., C. Wagner-Riddle and G. W. Thurtell. 1999. N_2O flux from a solid dairy manure pile determined with a micrometeorological mass balance technique. Can. Soc. Agrometeor., Agric. Institute of Canada, August 8-10, Charlottetown (oral presentation).

manures as a source of nitrous oxide: a laboratory study. Can. Soc. Agrometeor., Agric. Institute of Canada, July 5-8, Vancouver (poster presentation).

Brown, H., G. Dias, C. Wagner-Riddle and G.W. Thurtell. 1997. Nitrous oxide, nitric oxide and ammonia fluxes following a fall application of swine manure. Workshop on Greenhouse Gas Research in Agriculture. Agriculture and Agri-Food Canada/Green Plan. March 12-14, Sainte-Foy (poster presentation)

Furon, A.C., Warland, J. S. and Wagner-Riddle, C. 2002. A multi-layer model incorporating lagrangian dispersion for scaling up from leaf to canopy. 25th Conference on Agricultural and Forest Meteorology, May 20-24, Norfolk, Virginia. (oral presentation, 2nd prize for student oral presentation).

Furon, A. C., J. S Warland and C. Wagner-Riddle. 2002. 'A multi-layer model incorporating Lagrangian dispersion for scaling up from leaf to canopy.' AMS 25th Conference on Agricultural and Forest Meteorology, May 20--24, Norfolk, VA.

Jaysundara, S., Wagner-Riddle, C., Parkin G., Voroney, R.P., and Kay, B.D. 2001. Tracing the fate of fertilizer N applied to corn in two contrasting soil management systems. Annual Meeting of the Canadian Society of Soil Science, August 2-4, Guelph, ON (poster presentation).

Maggiotto, S.R., and Wagner-Riddle, C. 2000. Winter and spring thaw measurements of N_2O , NO and NO_x fluxes using a micrometeorological

method. 6th International Conference on Air-Surface Exchange of Gases and Particles. July 3-7, Edinburgh, UK. (oral presentation).

Maggiotto, S.R., and Wagner-Riddle, C. 2000. Winter measurements of N₂O, NO, and NO₂ fluxes using a micrometeorological method, following fall applications of various fertilizers. 34th Congress Can. Meteorol. And Oceanographic Soc. May 29 - June 2, Victoria, BC.

Maggiotto, S.R., and Wagner-Riddle, C. 1999. Nitrous and nitrogen oxide emissions from turfgrass fertilized with ammonium nitrate, urea, and slow-release urea. Can. Soc. Agrometeor., Agric. Institute of Canada, August 8-10, Charlottetown (oral presentation, 1st prize for student presentation).

McCoy, A., G. Parkin and J. S. Warland . 2002. 'Effects of Agricultural Management Practice on Soil Water Budget.' CSSS Annual Meeting, May~18--21, Banff, AB.

Mclaughlin, N.L. and Wagner-Riddle, C. 2002. Field evaluation of methods for reduction of N₂O emissions. 25th Conference on Agricultural and Forest Meteorology, May 20-24, Norfolk, Virginia. (oral presentation, 3rd prize for student oral presentation).

McLaughlin, N.L., and Wagner-Riddle, C. 2001. Field evaluation of management systems for reduction of N₂O emissions. Can. Soc. Agrometeor., Agric. Institute of Canada, July 10, Guelph, ON (oral presentation).

McKeown, A. W., J. Warland and M. R. McDonald . 2002. Cool season crop production trends: a possible signal for global warming. XXVI International Horticultural Congress. Presentation Tues August 13.

Roy, J. W., S. Clegg, J.C. Hall, G. Parkin, and C. Wagner-Riddle. 1998. Biodegradation of dicamba applied to turfgrass. Can. Soc. Soil Sci., Agric. Institute of Canada, July 5-8, Vancouver (oral presentation).

Thompson, A.G., Wagner-Riddle, C., Fleming, R., and MacAlpine, M. 2001. Methane and Nitrous Oxide emissions from a liquid swine manure composting system. ASAE 94th Annual International Meeting, August 1, Sacramento, USA (oral presentation).

Thompson, A.G., and Wagner-Riddle, C. 2001. Quantifying emissions of nitrous oxide and methane from anaerobic storage of liquid swine manure in

Southern Ontario. Can. Soc. Agrometeor., Agric. Institute of Canada, July 10, Guelph, ON (oral presentation, , 1st prize for student presentation).

Wagner-Riddle, C. 2001. Comparing cropping systems: effects on nitrous oxide emissions. Can. Soc. Agrometeor./ Can. Soc. Agronomy, Symposium on Cropping Systems and Environmental Quality, Agric. Institute of Canada, July 9, Guelph, ON (oral presentation).

Wagner-Riddle, S.R. Maggiotto, and G.W. Thurtell. 1999. Comparison of long-term N₂O flux estimates using several criteria to calculate eddy diffusivities. Can. Soc. Agrometeor., Agric. Institute of Canada, August 8-10, Charlottetown (oral presentation).

Wagner-Riddle, C. S.R. Maggiotto, G.W. Thurtell, and J. Webb. 1998. Fluxes of nitrous and nitrogen oxide after application of various fertilizer types to ryegrass. American Geophysical Union, Fall Meeting, Dec 6-10, San Francisco, CA. (poster presentation)

Wagner-Riddle, C. 2001. Measurement of greenhouse gas emissions from manure storages. CSAE/SCGR-NABEC, CSAS, CSAM, Joint Session on Gaseous emissions and nutrient management from livestock, Agric. Institute of Canada, July 11, Guelph, ON (invited, oral presentation).

Wagner-Riddle, C. and G.W. Thurtell. 1997. Nitrous oxide emissions from agricultural fields during winter and spring thaw as affected by management practices. International Workshop on Dissipation of N from the Human-N cycle, and its Role in Present and Future N₂O Emissions to the Atmosphere. May 22-24, Oslo, Norway. (poster presentation).

Wagner-Riddle, C., Park, K. H., and Thompson, A. G. 2002. Methane and nitrous oxide fluxes from liquid swine manure in storage determined with a micrometeorological mass balance technique. 25th Conference on Agricultural and Forest Meteorology, May 20-24, Norfolk, Virginia. (oral presentation).

Wagner-Riddle, C., Thurtell, G.W., Wenzel, R. 2000. Methane and nitrous oxide fluxes from a solid dairy manure pile. Can. Soc. Agrometeor., Agric. Institute of Canada, July 18, Winnipeg, MB (oral presentation).

Wagner-Riddle, C., Brown, H. A., Thurtell, G.W., and Wenzel, R. 2000. N₂O flux from a solid dairy manure pile determined with a micrometeorological mass balance technique. 6th International Conference on Air-Surface Exchange of Gases and Particles. July 3-7, Edinburgh, UK. (poster presentation).

Warland, J. S. and M. D. Novak. 2002. Numerical simulation of

turbulent kinetic energy downwind of varying-width shelters.' AMS 25th Conference on Agricultural and Forest Meteorology, May 20--24, Norfolk, VA.

Warland, J. S., K. Taillon and G. W. Thurtell. 2002. 'Comparison of identical eddy covariance systems in various configurations .' AMS 25th Conference on Agricultural and Forest Meteorology, May 20--24, Norfolk, VA.

Warland, J., Dias, G., Wagner-Riddle, C., and Thurtell, G.W. 2000. Field tests of a micrometeorological system for ammonia flux measurement using TDL technology. International Conference on Air-Surface Exchange of Gases and Particles. July 3-7, Edinburgh, UK. (poster presentation).

Watt, S, Wagner-Riddle, C., and G. Edwards. 2002. Field evaluation of passive samplers and deposition velocity for NO₂. 25th Conference on Agricultural and Forest Meteorology, May 20-24, Norfolk, Virginia. (poster presentation)

Watt, S, Wagner-Riddle, C., and G. Edwards. 2002. Field evaluation of passive samplers and deposition velocity for NO₂. 25th Conference on Agricultural and Forest Meteorology, May 20-24, Norfolk, Virginia. (poster presentation)

Webb, J., C. Wagner-Riddle and G.W. Thurtell. 1997. Effect of fertilizer type on nitrous oxide and nitric oxide from turfgrass. Workshop on Greenhouse Gas Research in Agriculture. Agriculture and Agri-Food Canada/Green Plan. March 12-14, Sainte-Foy (poster presentation)

Book Reviews:

Wagner-Riddle, C. 2002. Book Review: *Modelling Soil-Biosphere Interactions* by Christoph Müller, *CABI Publishing, Cambridge, 2000, 354 pp.*, ISBN# 0 85199 353 2. Agric. For. Meteorol. 111:153-155.

Theses completed (2000-2002)

March 2002 - Andrew G. Thompson (M.Sc.)
Nitrous oxide and methane emissions during the composting of liquid swine manure.

January 2002 - Shannon A. Watt (M.Sc.) (co-advised with Grant C. Edwards)
Field evaluation of passive samplers and the deposition velocity for nitrogen dioxide over turfgrass.

December 2000 - Selma R. Maggiotto (Ph.D.)

Thesis Title: Fluxes of oxidized nitrogen gases from fertilized agricultural fields.

Nayyar, V. 2002. A laboratory study to measure the fluxes of nitrogen oxides and the biophysical controls for their deposition in soybean leaves. M.Sc. thesis. (Will be completed this semester.)

Watt, S. 2002. Field evaluation of passive samplers and the deposition velocity of nitrogen dioxide. M.Sc. thesis. (Publication in preparation.)

Technical Reports

Galle, B, C. Wagner-Riddle, L. Klemetsson. 2001. Trace Gas Analysis, Optical Methods, *In*: Concerted Action, Task 2: Joint European Report on Measurement Technologies for the estimation of Greenhouse Gas Fluxes in Arable and Animal Agriculture. Report (FAIR3-CT96-1877).

2. Highlights of Agrometeorological Activities, Eastern Cereal and Oilseed Research Centre
Agriculture and Agri-Food Canada

1. Agrometeorological activities are concentrated in a study entitled: Agroclimatic Resource Assessment in a Changing Climate. The objective of the study is to develop methodologies and to carry out agroclimatic resource assessments for current and forecast climate scenarios to identify impacts, opportunities and adaptation strategies. The study leader is Henry Hayhoe and the collaborators are Andy Bootsma, and Reinder DeJong. Others involved in Agrometeorological related activities include S. Gameda, W. Baier and D. Stewart. Activities and productivity within the study include:

a) A technical bulletin on Crop Heat Units available for corn and other warm-season crops in Ontario published in the mid-90's is now available on the Internet at: <http://res2.agr.ca/ecorc/staff/bootsma/chu2/chu2e.htm> (A. Bootsma)

b) Results of collaborative research with the Soils and Crops Research and Development Centre in St. Foy on potential impacts of climate change on winter survival of perennial forage crops and on fruit trees in eastern Canada (including Ontario) are being summarized and drafted into two scientific papers. The scientific paper on winter survival of forage crops was accepted and will soon be published in the Agronomy Journal. (A. Bootsma)

c) An evaluation of potential impacts of climate change on yields and production of corn, soybeans and barley in the Atlantic region was completed.

Scientific papers based on this work have been drafted and submitted to a scientific journal for publication. (A. Bootsma)

d) A summary of results of recent research on potential impacts of climate change on agriculture in eastern Canada was presented at a workshop on "Climate Change and Agriculture in the Great Lakes Region" at Michigan State University on March 22, 2002. The presentation includes some analyses of potential impacts of climate change on agriculture in the Great Lakes region of Canada and the USA. The complete report is eventually to be available from the workshop web site at:

<http://www.geo.msu.edu/glra/workshop/index.html> (A. Bootsma)

e) A summary report on results of research on impacts of climate change on agriculture in eastern Canada and future plans for research in AAFC was presented at a C-CIARN Workshop in Guelph on March 1, 2002. A complete workshop summary report should be available on the web at:

<http://www.c-ciarn.uoguelph.ca/> (A. Bootsma)

f) We are presently investigating the potential impacts of climate change on agroclimatic indices in southern Ontario and Quebec. The analyses are being based on the output of 11 Canadian, UK and German GCM model runs for the periods 2010-39, 2040-69 and 2070-99 in relation to the baseline (1961-90) period. Use of multiple GCM runs is recommended by IPCC and will give some indication on the variation in the predicted outcomes. (A. Bootsma)

g) Research continued on examining relationships between incidence of vomitoxin (deoxynivalenol or DON) in grain corn in Ontario and seasonal weather conditions. At the present time, attempts are being made to test previously developed relationships between vomitoxin levels and precipitation and temperature variables on an independent set of vomitoxin data. Results of independent data tests indicated that regression relationships between vomitoxin and weather variables were not stable and that other methods of data analyses and model development are needed to produce a reliable predictive model of vomitoxin in corn in Ontario. (A. Bootsma)

h) An evaluation of climatic and soil factors contributing to winter survival of winter wheat using seven years of records of winter survival of winter wheat on a low lying plot on the Central Experimental Farm in Ottawa was carried out. Ice encasement of overwintering plants and extreme low temperatures were found to be the main factors causing winter kill. Two scientific papers have been drafted on the results. (H. Hayhoe)

i) Automated procedures have been developed and implemented to make the new climate reference station at the Ottawa weather site available in near-real

time on the intranet and on an experimental web site on the internet. (H. Hayhoe, A. Jones)

j) A report on communication of agrometeorological information in North and Central American countries was finalized for the WMO Commission for Agricultural Meteorology. (A. Bootsma)

k) We contributed to the development of metadata standards for agrometeorological data by participating in a World Meteorological Organization expert team on Integrated Data Management. (H. Hayhoe)

l) A chapter entitled, "Agricultural Meteorological Data, their Presentation and Statistical Analysis" for the revised WMO Guide to Agricultural Meteorological Practices is being written in cooperation with Dr. Raymond Motha of the USDA. (H. Hayhoe)

m) We conducted a successful test during the winter of 2001-2002 of the precipitation gauge for collecting solid and liquid precipitation which was developed through a collaborative agreement with Presentey Engineering. The results are being prepared for publication. (H. Hayhoe)

n) Reinder DeJong is currently on a work transfer to Enschede (Netherlands) to study methodologies for integrating remote sensing data into crop models.

2. A new study on the "Development of Climate Change Scenarios for the Agricultural Sector" which is supported by the Climate Change Action Fund has been initiated. This project will downscale GCM data spatially and temporally to develop national scenarios at a 0.5° grid scale from the latest Canadian and UK (Hadley Centre) GCM experiments. The outcome of the project will provide a consistent set of scenarios for researchers modelling the impacts of climate change and variability on agriculture, and for evaluating the capacity of different agricultural management practices in achieving GHG mitigation and agricultural sustainability. The study collaborators include: S. Gameda, A. Bootsma, H. Hayhoe, S. McGinn (Lethbridge), and E. Barrow (Regina, Environment Canada).

3. Other related research activities:

a) The first conceptual model for Fusarium infection of maize ears was published in the May issue of Phytopathology. This first model concentrated in describing infection through silks. Effort is being expended to model infection through wounds in the ear and comparing these two infection processes. (Doug Stewart)

b) Work is continuing on modelling soybean phenological development. We are studying interactions between temperature, photoperiod and the number

of dominant flowering genes on their effect on time from planting to first flower and from first flower to maturity. Recent work has shown that the rate of change of photoperiod as well as photoperiod itself can have an important influence on time from planting to first flower. As well, extremely cloudy days can delay flowering in soybean. Finally, the temperature response functions in the model change with the stage of growth as they did in maize. Low temperatures have a larger effect from first flower to maturity than from planting to first flower. Temperature response functions in the soybean model are also different than the response functions of our maize phenology model. (Doug Stewart)

c) A method has been developed to estimate total plant leaf area in maize by measuring the ear leaf area and counting the number of green leaves above and below the ear leaf. The Dwyer and Stewart equation relating maize leaf area to leaf number were used in these calculations. At this time, this method looks very promising and could eliminate a great deal of field work in maize research. (Doug Stewart)

d) A model is being developed to calculate pollen drift in maize canopies. The Cornell SPAM model was used to calculate wind velocity profiles in a maize canopy. A random walk model is being developed to superimpose effects of turbulence on these wind profiles to describe how wind moves pollen. We are comparing calculation of pollen drift to measurements of the frequency of yellow kernels in white kernel maize. Small blocks of yellow kernel maize have been planted at the centre of large blocks of white kernel maize. Both types of hybrids flower at the same time. Wind velocity (speed and direction) and temperature were measured continuously several meters above the maize canopy during the time of pollen drift. (Doug Stewart)

e) A flowering heat stress index for canola has recently been published in Crop Science with Malcolm Morrison. It quantifies quite well how high daily maximum temperatures affect yield in canola. (Doug Stewart)

Research

Hayhoe, H.N. 2000. Improvements of stochastic weather data generators for diverse climates. *Climate Research* 14:75-87.

Sivakumar, M.V.K.; Gommers, R.; Baier, W. 2000. Agrometeorology and sustainable agriculture. *Agric. For. Meteorol.* 103:11-26.

Morrison, M.J. and D.W. Stewart. 2002. Heat stress during flowering in summer Brassica. *Crop Sci.* 42:797-803.

Stewart, D.W., L.M. Reid, R.W. Nicol and A.W. Schaafsma. 2002. A mathematical simulation of growth of *Fusarium* in maize ears after artificial inoculation. *Phytopathology* 92:534-541.

Bulletin/Report

Baier, W. 2000. WMO/CAGM Related Achievements in Agricultural Meteorology. CAGM Report No. 83 World Meteorological Organization/TD-No. 1033. Secretariat of the World Meteorological Organization, Geneva, Switzerland.

Baier, W.; Boisvert, J.B.; Dyer, J.A. 2000. The Versatile Soil Moisture Budget (VB) Reference Manual. Eastern Cereal and Oilseed Research Centre, Research Branch, Agriculture and Agri-Food Canada, Ottawa, Ontario.

Bootsma, A. 2000. Communication of agrometeorological information in WMO Regional Association IV countries. Report presented at meeting of the WMO Commission for Agricultural Meteorology Working Group on the Communication of Agrometeorological Information, Geneva, Switzerland, 20-23 November 2000.

Martin, F.R.J., Bootsma, A., Coote, D.R., Fairley, B.G., Gregorich, L.J., Lebedin, J., Milburn, P.H., Stewart, B.J. and Van der Gulik, T.W. 2000. Canada's Rural Water Resources. In: Coote, D.R. and Gregorich, L.J. (ed.), *The Health of Our Water*, pg. 5-14. Agriculture and Agri-Food Canada, Research Branch, Publ. 2020/E.

Bootsma, A., Bélanger, G., Rochette, P., Castonguay, Y. and Mongrain, D. 2001. Potential impacts of climate change on winter survival of perennial forage crops in the Quebec region of Canada. In: *Preprints to 12th Symposium on Global Change and Climate Variations*, p.207-209. American Meteorological Society 81st Annual Meeting, 14-18 January, 2001, Albuquerque, NM, U.S.A. .

Bootsma, A., Gameda, S. and McKenney, D.W. 2001. Adaptation of agricultural production to climate change in Atlantic Canada. Final Report for Climate Change Action Fund Project A214. Agriculture and Agri-Food Canada, Eastern Cereal and Oilseed Research Centre, Ottawa. 30 pp. <http://res2.agr.ca/ecorc/staff/bootsma/report.pdf>

Bélanger, G., Rochette, P., Bootsma, A., Castonguay, Y. and Mongrain, D. 2001. Impact of climate change on risk of winter damage to agricultural perennial plants. Agriculture and Agri-Food Canada, Soils and Crops Research and Development Centre, Sainte-Foy, QC, Climate Change Action Fund Project A084 Final Report. 65 pp.

De Jong, R., Li, K.Y., Bootsma, A., Huffman, T., Roloff, G. and Gameda, S. 2001. Crop yield and variability under climate change and adaptive crop management scenarios. Agriculture and Agri-Food Canada, Eastern Cereal and Oilseed Research Centre, Ottawa, Ontario, Climate Change Action Fund Project A080, Final Report. 49 pp.

Hayhoe, H.N., 2000, Chapter 5: Application of multi-process models in agricultural meteorology. In: Agrometeorological Data Management, CAgM Report No. 81. World Meteorological Organization/TD-No. 1015. 98pp. Secretariat of the World Meteorological Organization, Geneva, Switzerland. p 39-49.

Hayhoe, H.N. 2001. Application of multi-process models in Agricultural Meteorology. In: Software for Agroclimatic Data Management, Proceedings of the Expert Group Meeting, October 16-20, 2000, Washington DC., USA. World Meteorological Organization/TD-No. 1075. 194pp. Secretariat of the World Meteorological Organization, Geneva, Switzerland. p 171-179.

Hayhoe, H.N. and Lapen, D.R. 2002. Using weather generators and agroclimate indices for climate change impact assessments. In: Preprints for the 13th Symposium on Global Change and Climate Variations, 82nd AMS Annual Meeting, 13-17 January 2002, Orlando, Florida, American Meteorological Society, Boston, MA. 3 pp.

Presentations/Lecture

Rochette, P., Bélanger, G., Bootsma, A., Castonguay, Y. et Mongrain, D. 2000. Changements climatiques et survie à l'hiver des plantes pérennes au Québec méridional. Paper presented at the annual meeting of the Quebec Society for Plant Protection, June 14-15, 2000, Saint-Félicien, Quebec. Abstract published in *Phytoprotection* 81(1): 42.

Sunohara, M.D., Hayhoe, H.N. and Lapen, D.R. 2001. Winter Wheat Survival: Delineating Relevant Landform Units. Agricultural Institute of Canada Annual Conference, July 9-11, 2001, Guelph, Ontario.

Hayhoe H.N. 2001. Report on Agrometeorological metadata requirements. Expert Team on Integrated Data Management Meeting, World Meteorological Organization, Commission for Basic Systems, 5 to 8 November 2001, Geneva.

Henry Hayhoe
Eastern Cereal and Oilseed Research Centre
Agriculture and Agri-Food Canada
Ottawa, Ontario
Canada K1A 0C6
Telephone: (613) 759-1524
Facsimilie: (613) 759-1924
E-mail: hayhoe@em.agr.ca

Appendix 1.

Committee minutes for June 14 2002.

ONTARIO AGROMETEOROLOGY RESEARCH AND SERVICES COMMITTEE

Friday June 14 2002, 10:00 to 15:00

Room 038 Richards Building.

Attending

A McKeown, T. Gillespie, Jon Warland, H. Hayhoe, I. Nichols, P. Brunner.

Summaries of activities were submitted via e-mail or disk and are attached. On a positive note, things are looking somewhat better on weather stations. Environment Canada has taken over sites at Harrow, Delhi and Vineland. This will improve the data situation. There are not enough good monitoring sites in Ontario, and it was estimated that at least 330 sites are required. Data from many sites are obtained from shared data. There is some interest by the Ontario Climate Advisory Committee on data sharing. MNR is developing a land information database, a data base of weather information could be useful. Of concern remains the funding and maintenance of weather stations at the Muck station, Guelph, Simcoe, Ridgeway and associated uncertainties with OMAF. The Ontario weather network is refurbishing some stations and providing some weather related services on a fee for service basis. They also have data on a web site, but there is no base budget for anything.

As 2002 will be a major reporting year for this committee it was decided to hold a think tank on agrometeorology related trends and needs by the industry.

1. Gas flux studies. There needs to be more work to improve our knowledge on gas flux to/from soils. The existing gas flux site is an excellent long term tool for atmospheric chemistry, and measures N₂O, CO₂ and H₂O. Other

gasses need to be added and soils N budgets determined long term. Water budgets, evapotranspiration measurement and improved irrigation scheduling need to be added as water management will become crucial, not only in fruit and vegetables but probably also in manure management as well. Water management will become a big issue in the near future. There will be increasing demand for water for irrigation and other purposes.

2. Manure storage and spreading. This is another big upcoming issue. The amount of storage required will depend on the number of animals and probabilities of precipitation and how the greenhouse warming may affect precipitation patterns. Related to the issue of water management in 1 above, the probability of water supply, hence irrigation requirements require study and use for both horticultural and field crops. Some seed corn contracts have been lost in the south west of the Province due to last years drought and no irrigation available. Drought also impacts the probability of supply and without irrigation, other crops may be lost to irrigated regions of the continent. If the climate become warmer and drier as predicted, irrigation use will have to expand. Liquid manures could be used for irrigation of some field crops under some circumstances. The probabilities are required for long term planning as well.

3. Risk of extreme events. (Probabilities). See comments on irrigation and manure storage above. Precipitation is not normally distributed, distribution towards the tails of the curve are more likely. Insurance companies are now very interested in extreme events. Climate change may well bring more frequent droughts, extremes in temperatures highs and lows i.e. frost events. These extremes are more important than climate means. Tables of probabilities of events need to be made for each region based on existing climate data.

4. Odours from farms. This is still an issue and will govern minimum separation distances. More work is required to reduce odours. Related to gas flux issues in 1, measurements of methane production/concentration are required.

5. Power turbines. Alternative energy sources are required. Information/studies are required to look into the feasibility and potential generation amount from wind turbines for on farm use or for sale of power. Probability of wind and strength of wind are required for this from the climate database.

6. Management for greenhouse gas reduction. Improved field practices to maximize yield and quality and minimize the loss of nitrogen. Improved manure management practices, generation and use of biogas as a fuel and composting are options for additional study/adoption.

7. Spray drift is a recurring issue (related to odours). Improved wind forecasts and spray technology would be useful to reduce drift.

8. Air quality. A number of points were raised in addition to the long standing smog and air pollution issues. Pollen species and counts for allergy issues, spread of GMO pollen, spores of bioterrorism agents were raised as potential issues. There is a need for real time data and dissemination to manage all of the above. This issue is also related to spray drift and odour management above. Air pollution is also linked back to the air quality needs above. This leads to all kinds of opportunities to improve data quality, management and problem solving. This of course requires ongoing support, funds and maintenance for success.

9. Pest management. Loss of Integrated crop management is the biggest disappointment to date. There are issues of resistance of insects and diseases, pesticide loading on crops and the need for good integrated weather based tools for crop management. There are new insects on the horizon with the need for weather based control models to be developed and validated and disseminated, eg soy aphid, corn beetle in sugar beet, Stewart's wilt in corn. There is an issue of extrapolation where no weather station exists (station density), real time information and data based driven modelling.

10. Greenhouse warming. These issues are related to most of the above. If current climate predictions are correct there will be considerable adaption to maintain our capacity to produce food, be done both locally, nationally and world wide. Some projections include hotter temperatures (especially nights) and more frequent precipitation events (drought/excessive). These adaptive measures will include, cultivars better adapted to extremes drought, heat cold; new insect and diseases; water conservation through irrigation scheduling; will hotter conditions reduce crop yield and hence food supply. Water supply and crop growth will affect nutrient management. Water borne or other tropical diseases getting a foothold in Ontario may impact food safety. Hotter temperatures probably will impact on nutritional quality of food. For planning purposes projections as to probabilities of weather the past and for say 2020, 2050 are required. These should be GIS mapped and updated as projections change. This will assist in long term planning for irrigation, waste holding requirements, facilitate research to reduce water consumption, heat stress of crops/animals and so on.

Appendix 11.
Committee Membership

Dr. Alan McKeown (Chair)

University of Guelph
Dept. Plant Agriculture
Box 587
Simcoe, Ontario
N3Y 4N5
519-426-7127 ext 329
519-426-1225 fax
amckeown@uoguelph.ca

Dr. Terry Gillespie
Land Resource Science
University of Guelph
Guelph, Ontario N1G 2W1
519-824-4120 ext 2447
tgillesp@lrs.uoguelph.ca

Dr. Jon Warland
Land Resource Science
University of Guelph
Guelph, Ontario N1G 2W1
519-824-4120 ext 6374
jwarland@lrs.uoguelph.ca

Dr. Murray Brown
195 Glenforest Road
Cambridge, Ontario N3C 1V6

Dr. Henry Hayhoe
Centre for Land & Biol. Res.
Agriculture & Agri-Food Canada
Ottawa, Ontario K1A 0C6
hayhoe@em.agr.ca

Dr. Ron Pitblado
Ridgetown College of Agricultural Technology
University of Guelph
Ridgetown, Ontario N0P 2C0
519-674-1605
rpitblad@ridgetownc.uoguelph.ca

Ian Nichols
Ridgetown College of Agricultural Technology
University of Guelph
Ridgetown, Ontario N0P 2C0
519-674-1532

inichols@ridgetowc.uoguelph.ca

Heather Griffiths
OMAFRA
Box 400 Ridgetown
Agronomy Building
Ridgetown College
NOP 2C0
519-674-1694
Heather.Griffiths@omafra.gov.on.ca

Peter Brunner

Box 7
Dinorwic Ont
P0V 1P0

pbrunner@moosenet.net

SCHEDULE THREE - A: Recommendation *Template*
ONTARIO AGROMETEOROLOGY RESEARCH AND SERVICES
COMMITTEE

1. RECOMMENDATION NUMBER:

Research and Services Priorities

Last year's priorities, needs and emerging issues are still valid:

Services

- quality of the weather radio network, holes in data and coverage, severe weather broadcasts.
- micro climate issues, especially for Hort crops wrt predictive models, data, reports, distribution to end users.
- look across borders for working models.
- diagnostics for environmental damage.
- monitoring of smog effects on crops.

Research

-develop models for other crops for example:

- IPM,
- Irrigation,
- insects, eg corn borer in peppers,
- not having IPM programs may be barriers to new Pesticide

Registration

-identify, acquire, validate models from other locations. Adapt those suitable and develop models to fill gaps.

Emerging issues carried forward from 2000.

- adapting agricultural production systems to climate change and detecting effects of climate change on crop yields.
- carbon sequestering by no-till
- air pollution, with the early and number of smog days this year, air pollution injury was noticed virtually everywhere in Ontario. Most crops are known to be sensitive and crop damage needs to be accounted for.

Irrigation scheduling, access to water, water use, competition for water, nutrient management will be increasingly important even without Global Warming. Evapotranspiration is the basis of irrigation scheduling models. However, the two models that are used do not agree in Ontario. One works well in the Guelph area, the other works well in Harrow. Outside of these areas results do not agree. Thus in addition to work on scheduling, water use efficacy, work is needed on evapotranspiration models that work across the Province.

2001-1R. Continue to support work to measure and model of greenhouse gasses, expand research on diffusion/dispersion of various gasses (eg. odours) in agricultural situations. Continue with research on management systems for nitrogen and organic wastes. There is a lot of uncertainty in climate change prediction and current spatial resolution is not adequate for agriculture uses. We need to update climate impact analyses on agriculture as new climate predictions become available.

2001-2R. Continue to support the development and testing of weather based predictive models for: use in applications such as pest/disease management, nutrient management, crop growth models and irrigation scheduling. Models need to include wide area to site specific predictions depending on the needs of the crop and grower. A better understanding of water budgets, supply and estimating potential evaporation for use in irrigation scheduling models is required.

2001-3R. Quantify the impact, benefits and detriments of climate change and how to adapt to climate change and increased variability. Develop improved crop management systems, including cultivars adapted to warmer, more variable climate. This work is required to maintain sustainability and security food supply for Canadians.

2001-4R. Smog damage is becoming an issue with increased number of smog days and injury.

The damaged needs to be monitored and accounted for in crop yields.

2001-1S/R Continue to attack the problem of deteriorating quality and availability of weather data in Ontario.

There has been considerable improvement with activities of the Ontario Weather Network.

More co-operating stations and commercial clients have signed up in 2001. The issue about autostation maintenance, repair and replacement is still a major issue.

See the 2001 report

2. ISSUES:

1. Gas flux studies.
2. Manure storage and spreading.
3. Risk (Probabilities) of extreme events, climate variability and the effects thereof.
4. Odours from farms.
5. Power turbines.
6. Management for greenhouse gas reduction.
7. Spray drift is a recurring issue (related to odours).
8. Air quality.
9. Pest management.
10. Greenhouse warming.

3. SOURCE:

OARSC

4. OASCC LINKAGES:

5. TARGET AGENCY:

OMAF, AG CANADA, MSC, U of Guelph

6. TITLE:

Understanding and adapting to the greenhouse effect and climate change.

7. DETAILS:

Increase funding and activities on all the above issues

8. BACKGROUND:

The climate of an area or country determines the amount and type of food to be grown, hence the ability to feed the population. The availability and quality of the food determines economic health and quality of life of the population. Insufficient food production leaves a population not only short of food or

nutrition but at the mercy of other populations with food, ie a strategic situation occurs.

The common Agrometeorology issue in all the above is the Greenhouse effect or Climate Change, identifying the science behind, and of course adapting to climate change. The effects of climate on production seem to have been ignored in recent years. One such aspect is the variability of climate on production and was raised in a paper presented at the ISHS congress in Toronto in 2002 by McKeown et al and submitted for publication in *Acta Hort.* The following is an excerpt from this paper. (see also the research results section below).

Yield of cole crops, rutabaga and potatoes were found to decrease with warmer average temperature, number of days $> 30^{\circ}\text{C}$, and with fewer days with precipitation. Higher temperatures probably will increase heat related quality disorders and possibly reduce vitamin content. Studies in US states adjacent to Ontario have shown high variability of yield of field crop yields from about 1885 to the early 1950's followed by a period of benign climate until the early 1970's followed by a significantly more variable climate (Andresen et al., 2001). This is, of course the period of time which most people use as "normal" climate and is the basis of the 1950 - 1980 climate normals. It appears the climate is normally more variable than this period in time. This is of course, the period of time of greatest Agricultural and technological advancements. Basing normal climatic expectations on this period is risky, notwithstanding the effects of the Greenhouse warming. A component of variability was identified as due to ENSO events for field crops (Phillips et al 1999) and vegetables (Park et al 2002). Interannual climate variability is one of the greatest risks farmers face either from direct effects or effects on pests, fertilizer efficacy, or price, hence the effect on a nations food supply. One climate change projection suggests about 48 hot days ($>30^{\circ}\text{C}$) in the London area as opposed to the 1951-1980 climate normals of about 9 (Wheaton, 1999). Based on our results, this may have significant results. Estimated changes in the agricultural system by Wheaton include: longer growing seasons, more frequent droughts and wet spells, more frequent and intense heat waves, fewer cold spells in winter, increased risk of soil erosion by wind and water, decreased snow cover, increasing demands and conflicts over water, decreased river flows and levels, northward expansion of weed, insect and disease ranges, increased disease and pest pressure, decreasing air and water quality. All of the possible outcomes will impact on agricultural production. While cultivars are selected for yield, disease resistance, visual quality, quality pertaining to human nutritional components is not usually taken into account. We believe this is of concern in relation greenhouse warming issues. High temperatures are regarded to result in less vitamin C content. Temperatures less than 20°C favour vitamin C, $10 - 15^{\circ}\text{C}$ favour B vitamins in green vegetables. Warm season tomatoes had higher B vitamins

at 27 - 30 ° C which indicates potential differences in vitamin responses and concentrations between cool and warm season vegetables. Thus, with the cool season crops at least, not only do higher temperatures have the potential to reduce growth, increase visual quality disorders but in addition have the potential to reduce vitamin C content. This aspect is of great consideration in human nutrition, and since Vitamin C has had little work in the English speaking countries (Mozafar, 1994), a better understanding of genetics, climate production practices on this important human nutrient is warranted.

Crop yield trends, along with rising temperatures, show decreased and more variable yields with warming temperatures. While not conclusive proof of greenhouse warming vs natural variation, it suggest that if this trend continues we can expect lower more variable yields impacting on supply, quality and pricing. Unless, management systems, cultivars etc., are developed to take variability and heat, both for yield, visual and nutritional quality into account, highly variable, poorer yields and quality may result. Higher temperatures will place more demand for irrigation water and scheduling, work to develop cultivars with more stable yield and nutrient content over widely varying climate conditions.

Failure to understand and develop means to overcome effects of greenhouse warming and climate change will have severe impacts on food production and our ability to feed ourselves. Climate induced crop failures have had significant impacts humans throughout our history. It is false to assume that we are immune to such changes. We owe our existence to a few inches of topsoil and timely precipitation, and heat.