Spatial Analysis of the Adoption of Nutrient Management Related Best Management Practices in Ontario

April 2005 – March 2010

Prepared by Elisabeth Woyzbun
Regional Land Analyst, Agri-Environment Services Branch
Agriculture and Agri-Food Canada

Executive Summary

The Canada-Ontario Environmental Farm Plan (EFP) partnership undertook a spatial analysis of the adoption of nutrient management Best Management Practices (BMPs) in Ontario. The purpose of the analysis was to determine the effectiveness of the EFP as a ‘place based’ assessment tool for targeting or accelerating BMP project adoption in geographic areas at risk of elevated nutrient levels and to contribute to the measurement of the performance of the EFP and the Canada-Ontario Farm Stewardship Program (COFSP).

The spatial analysis utilized data from the COFSP database for farms receiving funding for BMP projects from April 2005 to March 2010 and from the 2006 Census of Agriculture. The data were summarized at a municipal scale as numbers of projects per municipality and these summary data were mapped with geospatial analysis using ArcGIS. The BMP project data summarized by municipality was also correlated with census variables through ordinary least squares linear regression analysis. An initial spatial analysis by watershed was also attempted and is provided in the appendix.

Manure and nutrient production from livestock were calculated using the methods discussed in “A Geographical Profile of Manure Production in Canada, 2001” (Statistics Canada, 2006). Total manure, nitrogen and phosphorus produced in each municipality were normalized by dividing by the hectares of farmland in each municipality. These normalized values were mapped and overlaid with the number of livestock nutrient management BMP projects adopted by municipality to show the relationship between the two sets of data.

The relationship between the adoption of livestock related nutrient management BMPs and the total amount (kg) of manure produced in a municipality is highly correlated (91 percent of the variation explained, R^2 =0.91; P value: <0.00001). As would be expected, the relationship is similar for livestock nutrient management related BMP adoption and the amount of phosphorus and nitrogen in this manure. In municipalities where there is a high production of livestock manure, or nutrients produced from manure, there is higher adoption of livestock nutrient management BMPs to address risks associated with manure.

To achieve a similar type of analysis for crop related nutrient management BMPs, the acreage of a municipality with commercial fertilizer applied according to the 2006 Census of Agriculture was mapped in conjunction with the number of crop nutrient management BMPs. Municipalities with the largest area of farmland receiving commercial fertilizer were also the municipalities with the highest number of crop related nutrient management BMPs adopted. The relationship between the adoption of crop nutrient management BMPs and the acreage of field crops with commercial fertilizer applied is also highly correlated (87 percent of the variation explained, R^2 =0.87; P value: <0.00001). Again, risks associated with fertilizer use are being addressed through crop nutrient BMP adoption and the level of adoption is proportional to the risk.

There are some municipalities where fewer BMPs are being adopted despite relatively large amounts of manure nutrients produced. This phenomena tends to occur in regions with a high percentage of rented land (Halton and Peel regions) or where nutrients (in the form of manure) are exported out of the region, such as occurs where there is a large concentration of poultry operations (Niagara region).

The spatial and regression analysis found that there is a high correlation between the number of nutrient management related BMPs adopted across the province (whether crop or livestock related) and the areas where there may be increased risk of elevated nutrients in the environment (whether from fertilizer application or manure production). The EFP helps the producer identify priority environmental risks and measures to reduce those risks such as through nutrient management in the context of their own farm. The COFSP helps accelerate BMP adoption and funding is only available for actions to significantly address identified risks. While the EFP is a universally accessible program to farmers in Ontario, this analysis provided evidence that the implementation of the EFP in Ontario results in place-based, targeted action in the province on priority issues and areas. The EFP and COFSP help target the adoption of livestock and/or crop nutrient management BMPs in municipalities with the highest production of manure or use of fertilizer in the province.

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1.0 Introduction

In collaboration with members of the Canada-Ontario Environmental Farm Plan (EFP) partnership, a spatial analysis of the adoption of nutrient management Best Management Practices (BMP)s in Ontario was conducted to determine the effectiveness of the EFP as a 'place based' assessment tool for targeting or accelerating BMP adoption in geographic areas at risk of elevated nutrient levels and to contribute to the measurement of the performance of the EFP and Canada-Ontario Farm Stewardship Program (COFSP). While these programs are broadly available across Ontario, the EFP and COFSP are both programs that can be considered to be place-based as they help target BMP adoption on the regional and site-specific agricultural landscape.

The EFP partnership in Ontario consists of Agriculture and Agri-Food Canada (AAFC), Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA), and members of the Ontario Farm Environmental Coalition (OFEC) represented by the Ontario Federation of Agriculture (OFA) and the Ontario Soil and Crop Improvement Association (OSCIA). Data collected on the adoption of nutrient management related BMPs under the Canada-Ontario Farm Stewardship Program (COFSP) from April 2005 to March 2010 were analysed by (i) municipality, (ii) watershed, and (iii) commodity type. The analysis compared the number of nutrient management BMPs that were adopted through COFSP with the distribution of livestock production (manure generation) and crop production (fertilizer use) in Ontario.

2.0 Background

2.1 Environmental Farm Plan

The EFP is a voluntary and confidential educational program for producers to self-assess areas at environmental risk on their farm landscape and to develop an action plan to address the issues. The environmental risks may be either inherent risks such as soil type or the depth to a water table, or may be as a result of management of operations on the farm.

The program began in 1992, and has evolved through three versions (editions). Currently, in the third edition, producers determine environmental risks on their farms through a series of 23 worksheets and up to 310 questions during a 2-day workshop. Approximately 60 of these questions relate directly to nutrient management. The producer self-assesses different situations on their farm by rating their current situation from a 1 to a 4 (a rating of 4 represents the best possible situation that has the lowest potential for risk to the environment, and a 1 rating represents situations that have the highest potential to negatively affect the environment). Producers develop an action plan that changes practices to improve situations that are given a rating of a 1 or 2. The action plan is then confidentially peer-reviewed by a locally appointed group. The producers are encouraged to implement BMP projects that address practices or situations that represent the highest risk to the environment. Those BMP projects may be eligible for government cost-share funding that will improve practices or situations of the operation from a risk rating of a 1 or a 2 to either a 3 or a 4. Risk ratings of 3 to 4 demonstrate that best practices are in place and that they meet or even exceed legislated requirements. Participating in the EFP in Ontario is one of the key eligibility requirements for funding through the COFSP.

2.2 Canada-Ontario Farm Stewardship Program

COFSP is a cost-share program funded by AAFC and OMAFRA originally under the Agricultural Policy Framework (APF) and now under the Growing Forward (GF) Best Practices Suite. The program is administered by OFA acting on behalf of OFEC and is delivered to the agricultural community by OSCIA. Participation in COFSP is voluntary and its goal is to encourage producers to improve the management of their agricultural operations through the adoption of BMPs that are new to their farm business and contribute to improved water and air quality, improved soil productivity, enhanced wildlife habitat and/or result in energy conservation. Many of these BMPs also contribute to improved production efficiency and farm profitability.

With COFSP, all registered farm businesses across Ontario that have completed a third edition EFP with a peer-reviewed action plan are eligible for cost-share funding. Environmental practices or situations that are identified as having a risk rating of 1 or 2 in a producer's action plan can be addressed by choosing one or more BMPs from the 36 cost-shared BMPs in APF or 28 in GF through the program to receive either 30 or 50% of a BMP project's cost up to varying caps from $2,000 to $30,000 in APF and GF. During COFSP (April 2005 to March 2010) producers received funding for over 18,000 projects in Ontario. Of these projects, 7791 of them were related to nutrient management. The total cost of these projects was $161,969,151, of which $48,306,521 was funded through COFSP, with the rest provided by the producers themselves and from other sources of funding.

2.3 Nutrient Management

In agriculture, nutrients, mainly in the form of mineral fertilizers and animal manure, are added to the soil to sustainably grow crops. The addition of fertilizers and manure improves crop yield by providing nutrients that are essential to plant growth, primarily the macro-nutrients nitrogen and phosphorus. Nutrients can also be added to the land in the form of crop residues, composts, leguminous crop roots and even rainfall.

The goal of nutrient management in a cropping system is to match crop uptake with nutrient addition and thereby maximize the uptake of applied nutrients by the crop. Practices that help a producer deliver nutrients at the right rate, at the right time, in the right form and in the right place will improve nutrient use efficiency and help reduce off-site losses of nutrients. Sound nutrient management systems can minimize nutrient losses from the cropping system while providing adequate soil fertility and nutrient availability to ensure realistic yields (USDA-NRCS, 2011).

Management practices to optimize the use of applied nitrogen and minimize losses from the cropping system include:

- Minimizing the amounts of N applied/required by: following OMAFRA recommendations; using side-dress technologies; accounting for manure and previous crop N in application rates; and, using GPS and variable rate controllers
- Reducing volatilization as ammonia by: incorporation, injection or drop nozzles; and avoiding application when hot, dry or windy

- Reducing the risk of nitrate leaching by: having a cover crop with fall applied manures; rotation with deep rooted crops to take up N; using fertigation; and, using split N applications
- Reducing denitrification through: improved soil drainage; and slowed nitrification (application at cooler temperatures, or with nitrification inhibitors)

Management practices to optimize the use of applied phosphorus and minimize losses from the cropping system include:

- Minimizing the amounts of P applied/required by: following OMAFRA recommendations; using fertilizer placement technologies; accounting for manure and previous crop P in application rates; and, using GPS and variable rate controllers
- Soil testing of P to ensure that phosphorus is not being applied in excess of the crop removal, or beyond what is needed for probable crop response
- Use of erosion control measures such as conservation tillage, grassed water ways, cover crops, and water and sediment control basins to prevent the detachment and movement of P attached to soil particles

Best Management Practices can be categorized or described by their mechanism to mitigate risk. Mechanisms of risk mitigation include: managing nutrient source/form, managing nutrient storage/transfer, managing rate and type of nutrient application, managing timing of application (which influences immobilization, transformation and/or uptake of nutrients) and managing transport (i.e., maximize retention of nutrients in field). Often a suite of BMPs utilizing multiple mechanisms to reduce risk is needed to optimize nutrient utilization or improve nutrient use efficiency and mitigate losses to the environment. The use of a combination of these practices has not been considered in this analysis.

2.4. COFSP Nutrient Management Best Management Practices

The characteristics of nutrient sources, application, uptake, and losses are considered in the worksheets of the Ontario EFP. Questions about nutrients in the worksheets help direct producers to BMPs which will help improve their nutrient use efficiency and reduce their risk of nutrient losses from crops to the environment. Through COFSP, producers were able to choose from 36 BMP categories during APF or 28 BMP categories during GF, of which 11 address nutrient management. In total, 33 best management practices (identified as “codes”) were identified under the 11 categories as practices that target nutrient management issues. Members of the Ontario Environmental Farm Plan Partnership selected these practice codes to represent nutrient management related BMPs in this and previous spatial analyses (i.e. Schmalz and Brown, 2008). These practices relate either to livestock operations or crop production, while a few of the practices are relevant to both. The list of categories and practice codes used in this analysis and their descriptions can be found in Table 3, Appendix I.

The most commonly funded BMPs (practice code) associated with nutrient management based on risk identification from producer’s EFP Action Plan were precision agriculture projects using Global Positioning Systems (GPS) (1301/1403), nutrient management planning (2401), manure storage and handling (0101 and 0104), and controlling barnyard runoff (0501). For a summary of the most commonly adopted BMPs by municipality, watershed and commodity type, please refer to Tables 4 to 8, Appendix I. These five BMPs represent 69.3% of the total nutrient management BMP projects adopted through COFSP during the study period and are described in more detail here.

Precision agriculture technology helps reduce the amount of over-application of fertilizer to the soil. GPS systems (1301/1403) typically involve installing variable rate controllers to improve the precision of applying nutrients and pest management products. Precision agriculture has been shown to reduce the overall nitrogen application as well as reduce the amount of leached nitrogen (Bongiovanni and Lowenberg-Deboer, 2004).

Producers took advantage of COFSP to develop Nutrient Management Plans (NMP; 2401). These NMP were prepared by provincial government-certified nutrient management planners and implemented across Ontario. These projects allowed producers to identify opportunities for improved nutrient efficiencies within their systems and develop an in-depth understanding of the environmental impacts surrounding livestock by-products. The in-depth plan involves accounting for and recording all of the nutrients that are present on the farm, which of these will be needed and when depending on crops to be grown, along with how much will be applied to their land base (OMAFRA, 2006). Nutrient management planning ensures livestock producers have the land base and storage to support the appropriate utilization of their manure nutrients for recycling in crop production. The concepts and process of nutrient management planning are equally applicable to producers who do not produce or utilize manures.

During the program, livestock producers installed storage and handling systems (0101 and 0104) for solid and liquid manure. Proper manure storage is an important factor in protecting water resources in close proximity to livestock facilities. These projects result in increased storage capacity for manure, and thereby provide the farmer with greater flexibility with regard to the timing of manure application and avoid sub-optimal application conditions (i.e., frozen ground) (Goss et al., 2002). The size of the storage facility is very important since it determines how much manure can be stored and how often and how much manure is spread (OMAFRA and MOE, 2005) so that the producer can find the optimum time to apply manure that balances environmental risks with their crop rotation and, equipment and labour availability. These types of BMP projects help reduce the quantity of manure and nutrients potentially entering waterways through potential runoff and covered liquid manure storages decrease the amount of nitrogen being lost to volatilization.

BMPs to control runoff from farmyards and horticultural facilities help reduce the loading of sediment and nutrients to surface water (0501). Runoff control projects ensure that runoff is effectively contained and or directed to a proper treatment system or long-term storage facility. Producers may install eavestroughs on buildings surrounding barnyards that can help reduce the amount of clean water being introduced into yards containing manure. Vegetated filter strips (VFS) are also projects that have been shown to be effective, economical and environmentally sound treatment systems for barnyard runoff (OMAFRA and SRG, 2008; Cayley and Toombs, 1997).

2.5 Drivers for Adoption of Nutrient Management BMPs

There are drivers other than the Environmental Farm Plan and Canada Ontario Farm Stewardship Program funding that affect the adoption of nutrient management related BMPs. The following description of some of these drivers provide context for adoption and may also explain factors other than those selected as "place based" for this analysis that affect where BMPs are adopted.

2.5.1 Voluntary Stewardship

Farmers are stewards of the land and adopt BMPs to ensure they have clean water and healthy soil for the future. EFP and COFSP are complementary to this ongoing stewardship. The EFP is an educational process that helps educate and motivate producers to complete a risk assessment on their farm and develop an action plan. The EFP helps producers set priorities for BMP adoption on their farm and encourages continuous improvement. COFSP aids in and accelerates the adoption of the BMPs that were determined to have priority by the producers by providing financial incentives.

There are other drivers that help promote voluntary stewardship in Ontario. Producers have access to technical assistance from provincial and federal governments who can share information about new technology and practices. Conservation Authorities (CAs), local Soil and Crop Improvement Associations, stewardship councils and watershed groups can also provide important information and participate in local demonstrations with producers on topics including best practices and environmental concerns. Information is also available from farm organizations who promote new practices that would benefit producers. Producers are exposed to new ideas and services from the agri-businesses they work with. For example, equipment dealers help promote the use of no-till equipment while certified crop advisors and nutrient management consultants are recommending BMPs for nutrient management like GPS systems for precision agriculture. Voluntary stewardship is also enhanced by encouragement from neighbours. Information about BMPs can be passed on by word of mouth or from touring a neighbour's property.

There are many voluntary incentive programs in Ontario to help producers implement nutrient management BMP projects. Some of these incentive programs are associated with the EFP and are available across the province. Other programs are specific to certain areas, providing funding for a select list of BMPs. For example, the Lake Simcoe Farm Stewardship Program targets producers located in the Lake Simcoe watershed. There is also the Ontario Drinking Water Stewardship Program under the *Clean Water Act* (2007) which is designed for producers that have land located within a wellhead protection area or an intake protection zone. In Ontario, there are many CAs that provide Rural Water Quality Programs or Clean Water Programs in specific watersheds that provide additional cost-share for producers.

2.5.2 The Great Lakes Water Quality Agreement

The continued interest in the water quality of the Great Lakes has put a spotlight on agriculture and nutrient management in the Great Lakes watersheds. This interest in water quality is in part due to beach postings due to elevated bacterial levels. Another reason water quality, especially with regard to nutrient levels, is of public interest is due to recently recurring nuisance and/or toxic algal blooms and shoreline fouling, especially in Lake Erie. In 1972, the Great Lakes Water Quality Agreement (GLWQA) was signed by Canada and the United States as a commitment of both countries to restore and maintain the physical, chemical and biological integrity of the Great Lakes waters. The GLWQA was later revised in 1978 and amended in 1987. A recent review of the GLWQA, as well as renewed public interest in the health of the Great Lakes ecosystem, has resulted in the current re-negotiation of the GLWQA between Canada and the United States to update the Agreement and enhance its ability to address current and future threats to the Great Lakes ecosystem such as eutrophication, invasive species and climate change. The review and public discussion indicate that nutrients, in particular phosphorus, will continue to be a concern for the health of the Great Lakes, including the nearshore.

2.5.3 Regulations

Regulation of nutrient use and management in agricultural operations in Ontario occurs under the *Environmental Protection Act* (EPA) (1990), the *Ontario Water Resources Act* (OWRA) (1990) and more recently the *Nutrient Management Act* (NMA) (2002), the *Clean Water Act* (2007) and the *Lake Simcoe Protection Act* (LSPA) (2008).

The EPA contains a general clause (6) which prohibits the discharge of a contaminant into the environment in an amount above that prescribed by its regulations. Under the EPA, regulations set limits for releases to land, air, surface and groundwater. These regulations apply to all agricultural operations except those that deal with animal wastes, which are disposed of in accordance with both normal farming practices and the regulations made under the *Nutrient Management Act*, 2002.

The goal of the OWRA is to provide for the conservation, protection and management of Ontario's waters and for their efficient and sustainable use, in order to promote Ontario's long-term environmental, social and economic well-being. Section 30 of the OWRA has a general prohibition clause similar to the EPA, that states that every person that discharges or causes or permits the discharge of any material of any kind into or in any waters or on any shore or bank thereof or into or in any place that may impair the quality of the water of any waters is guilty of an offence.

Section 53 of the OWRA requires an approval for sewage work that collects, transmits, treats or disposes of sewage. Sewage refers to all types of wastewater, including process water, stormwater, and sanitary wastewater. Sewage systems are classified as either municipal/private sewage works or industrial sewage works. Wastewaters and stormwaters from agricultural operations, that are not managed under the Nutrient Management Act fall under this sewage classification.

In 2002, the NMA was passed in Ontario to improve the management of the application and storage of materials that contain nutrients such as manure. The NMA requires livestock producers to create a Nutrient Management Plan (NMP) (a plan of how nutrients will be applied to the land and the balance of the crop needs and amount of nutrients applied) or a Nutrient Management Strategy (NMS) (a strategy for the generation, storage and destination of a prescribed material (agricultural source material – manure, barnyard runoff, etc. or a non-agricultural source material – biosolids, anaerobic digestate, etc.)). There are different criteria in place to determine if a farm must possess a NMP or NMS. A NMS will help determine where livestock barns and manure storage facilities can be constructed and determines setbacks from surface water and wells. From 2004-2006, $20 million dollars was provided by the province to help existing operations become compliant with the new regulations through the Nutrient Management Financial Assistance Program (NMFAP). Several of the nutrient management BMPs supported by COFSP were "topped up" to higher percentages and caps to accelerate change on the landscape to become compliant with the new regulation.

The *Clean Water Act* created in 2007, aims to protect drinking water at the source. The Act mandated that Source Protection Committees in watersheds in Ontario create Source Protection Plans and identify surface water intakes, aquifers, recharge areas and surface water intake protection zones that are at risk of becoming contaminated or depleted. The Source Protection Plans may include policies that restrict or limit certain activities on properties that are located in designated wellhead protection areas and intake protection zones. In the past, this program has promoted voluntary stewardship by providing incentives to landowners situated in certain distances of municipal wells or municipal surface water intakes to adopt BMPs in conjunction with the EFP.

The LSPA was put in place in 2008 to improve the health of the Lake Simcoe watershed. The Lake Simcoe Protection Plan (2008), and its associated policies, was created as part of the Act to protect and restore the ecological health of the watershed. A key part of the LSPA is the recent Phosphorus Reduction Strategy (2008). This long-term strategy's target is to identify and reduce major sources of phosphorus from entering the Lake Simcoe watershed. All sources of phosphorus are included in the strategy including leachate from private septic systems, runoff from rural and agricultural areas, and effluent from sewage treatment plants. The Phosphorus Reduction Strategy is a 35-year, long-term strategy that aims to reduce the loading of phosphorus into the lake, from the current level of 72 tonnes per year to 44 tonnes per year. Financial incentives were provided to landowners to adopt BMPs that help prevent the entry of phosphorus into Lake Simcoe.

2.5.4 Market Signals and Industry Sustainability

Incentives and drivers to adopt nutrient management BMPs can also come from the industry and consumers. Traceability, food safety, and greening the supply chain are new issues that are coming to the forefront of agricultural sustainability. Producers' and commodities' reputations are at stake and cannot afford the negative publicity if traceability or food safety is compromised. They may incorporate nutrient management BMPs to improve traceability and food safety as well as reduce the risk to losing the market or consumer. The increased emphasis on consumer's access to local food is also a driver. By participating in local food programs like Local Food Plus, producers are required to adopt environmental practices and BMPs. Evidence to consumers that their food is sustainably produced, like food coming from farms with an EFP, is recognized by producers as becoming increasingly important for their social license to practice agriculture.

3.0 Methods of Analysis

In the process of administering COFSP, OSCIA collected confidential BMP project data from farms participating in the program. This information included the producer's municipality, major watershed (based on location in a Conservation Authority (CA)), and commodity type. These data were taken over a 5-year period (April 2005 to March 2010) and were analysed by municipality, which boundaries are determined by Statistics Canada's Census Divisions (CD). A detailed map of where CD are located across Ontario can be found in Figure 11 (Appendix I). Project data were also analyzed to a lesser extent at a watershed level (Appendix II) and by commodity type (Section 4.1.3). The analysis was conducted to observe the relationships between where nutrients are being used on the landscape and how this relates to where nutrient management projects are being implemented.

The relationships were observed through a spatial analysis as well as through a regression analysis. The type of regression analysis used was ordinary least squares linear regression performed using the Excel spreadsheet software data analysis functions.

This analysis does not include all the projects that are being adopted by producers across Ontario, but only those that have been implemented with COFSP funding. Producers are also adopting BMPs and completing their Action Plan without the additional financial help of the COFSP cost-share program, and therefore these data are not recorded or included in this study. There are also additional cost-share programs funded by various Ontario ministries and CAs (mentioned in Section 2.5.1) for which project adoption data are not included in the analysis.

The first step in the analysis was to examine the trends in the demographics of the participants in the EFP and COFSP across Ontario's counties and districts. To achieve this, different information was mapped and graphed to understand more about the farms participating in these programs. Farm Business Registration Numbers (FBRN) from the year 2009 were analyzed to see the percentage of registered farm businesses in Ontario that currently have an EFP. Farm businesses that gross more than $7000 in farm income annually are required by law to register their farm business and receive a FBRN (OMAFRA, 2011). A regression analysis was conducted by regressing the total number of peer-reviewed third edition EFPs against the number of FBRNs in Ontario in 2009 and using the R-squared value associated with the line of best fit as an estimate of how well these data sets were correlated.

To examine the correlation of net farm income to the number of nutrient management BMP projects adopted during COFSP, the total gross farm receipts and the total farm business operating expenses by census division for 2005 were taken from Statistics Canada's 2006 Census of Agriculture. The total net farm income was calculated by taking the difference between these two sets of data. A regression analysis was conducted by regressing the number of nutrient management BMPs adopted against the net income by municipality and using the R-squared value associated with the line of best fit as an estimate of how well these data sets were correlated.

When BMP project data are collected for COFSP, OSCIA records the major commodity type of the producer as declared by the producer. There are eleven commodity type categories that a producer can choose: beef (cow calf), beef (feeder), dairy, field crops, goats, hogs, horses, horticulture, poultry, sheep and other. The COFSP BMP data by commodity type was depicted using bar graphs. The total number of nutrient management BMP projects adopted by each commodity type, and the number of livestock nutrient management BMP projects compared to the number of crop nutrient management BMP projects by each of the commodities were graphed. Those practices that are applicable to both livestock and crop producers are counted in both the livestock and crop categories; thus in Tables 10-13 and Figure 4, the addition of livestock and crop projects will not add to the total nutrient management BMP projects. Those practices applicable to both livestock and crop producers are generally Farmyard and Horticultural Facilities Runoff Control projects (practice code 0501) and Nutrient Recovery from Waste Water (practice code 1701).The database is not able to distinguish for what purpose (crop or livestock) the practice was adopted and purposes can occur on the same farm. The three most commonly adopted BMP projects by commodity were also determined and displayed in Table 1.

The number of nutrient management BMPs were mapped by municipality prior to an in-depth analysis of the separate livestock and crop related nutrient management BMPs. The intensity of nutrient management BMP projects adopted during COFSP was calculated by normalizing the total number of nutrient management BMPs adopted during the study period by the square kilometers of farmland in each municipality, taken from the 2006 Census of Agriculture. This information was mapped using varying colours from red to dark green (from lowest concentration of BMPs to the highest concentration of BMPs in the municipality, respectively). Thresholds were created using ArcGIS' natural breaks (jenks) classification for graduated colours, and rounded for ease of viewing.

To observe the relationship of livestock related nutrient management BMP projects and livestock production, manure and nutrient production from livestock was calculated in each municipality using the methods discussed in "A Geographical Profile of Manure Production in Canada, 2001" (Statistics Canada, 2006). Using the coefficients (Appendix I, Table 9) from this document and livestock numbers from the 2006 Census of Agriculture, total manure, total phosphorus and total nitrogen produced from manure were calculated for each municipality and sub-sub drainage area. To calculate normalized manure production for agricultural area, the total amount of manure, nitrogen and phosphorus was then divided by total farm area of the municipality or sub-sub drainage area. The assumptions and limitations for these numbers are the same as stated in Statistics Canada, 2006. The data used for this analysis such as farm area and the number of animals per municipality were taken from Statistics Canada's 2006 Census of Agriculture on either a Census Division level directly or on a sub-sub drainage area from AAFC's Interpolated Census of Agriculture.

The calculated normalized manure production values, along with the amount of nitrogen and phosphorus produced from manure was mapped by municipality using a grading scale of colours, red to dark green (the highest amount of manure or nutrients produced to trace to no amounts produced, respectively). The normalized manure production and nutrient produced from manure by hectare of farm area were overlaid with the number of livestock nutrient management BMP projects adopted by municipality to show the relationship between the two sets of data. The BMP data were represented by dots of varying colour and size from small black to large white (least amount of BMPs adopted to most amount of BMPs adopted by census division, respectively).

The thresholds were created using ArcGIS' natural breaks (jenks) classification for graduated colours, and rounded for ease of viewing. A regression analysis was also conducted by regressing the number of livestock related nutrient management BMPs adopted against the total amount of manure or nitrogen/phosphorus produced from manure by municipality and using the R-squared value associated with the line of best fit as an estimate of how well these data sets were correlated.

To achieve a similar type of analysis for crop related nutrient management BMPs, the acreage with commercial fertilizer applied according to the 2006 Census of Agriculture was mapped in a similar fashion as the manure and nutrients for livestock nutrient management BMPs. To differentiate from the livestock analysis, other colours were chosen for commercial fertilizer area. The colours ranged from light yellow to red (little to no hectares with fertilizer applied to most area fertilized, respectively). The thresholds were created using ArcGIS' natural breaks (jenks) classification for graduated colours, and rounded for ease of viewing. This relationship was also analyzed using a regression analysis and using the R-squared value associated with the line of best fit as an estimate of how well these data sets were correlated.

Agriculture and Agri-Food Canada interpolates Statistics Canada's census data at a sub-sub drainage area level, which differs from the CA or county level that OSCIA records BMP adoption. The boundaries of these two scales vary greatly; therefore no regression analysis could be done to further compare the relationships of manure production and fertilizer use with nutrient management BMP adoption. The spatial analysis that was conducted on a watershed basis for nutrient management BMP project adoption can be found in Appendix II.

4.0 Results and Discussion

The results and discussion for the analysis by municipality are found in the following section. For further information on the ten municipalities, watersheds and commodities that adopted the most number of nutrient management BMPs, crop and livestock nutrient management BMPs, and the total number of projects, refer to Tables 10 to 13 (Appendix I).

4.1 Characteristics of Participating Farms

To gain a better perspective and more context on the types of farms that participate in EFP and COFSP, the number of farms participating in the EFP in each municipality across the province, the relationship of the number of nutrient management BMPs adopted and the net income of a municipality, and the nutrient management BMP breakdown by commodity type were evaluated.

4.1.1 Farms Participating in the EFP

Between 1993 and 2004, there were 27,317 EFP workshop participants, with 64% having had their EFPs peer reviewed (includes 2nd edition EFP). Between 2005 and 2009, 14,233 farm businesses participated in the 3rd edition EFP workshop (6,127 were returning workshop participants) and 10,505 farms had their EFPs peer reviewed.

Figure 1 depicts the number of peer reviewed 3rd Edition EFPs as of the end of 2009 compared to (regressed against) the number of FBRNs in 2009 in each municipality. Refer to Table 2 – Appendix II for numerical key to municipality name, as municipalities have been numbered in Figure 1. It shows that across the province, the number of peer reviewed EFPs in a municipality is highly correlated with the number of farms in that municipality ((R^2 0.80; P value: < 0.00001).

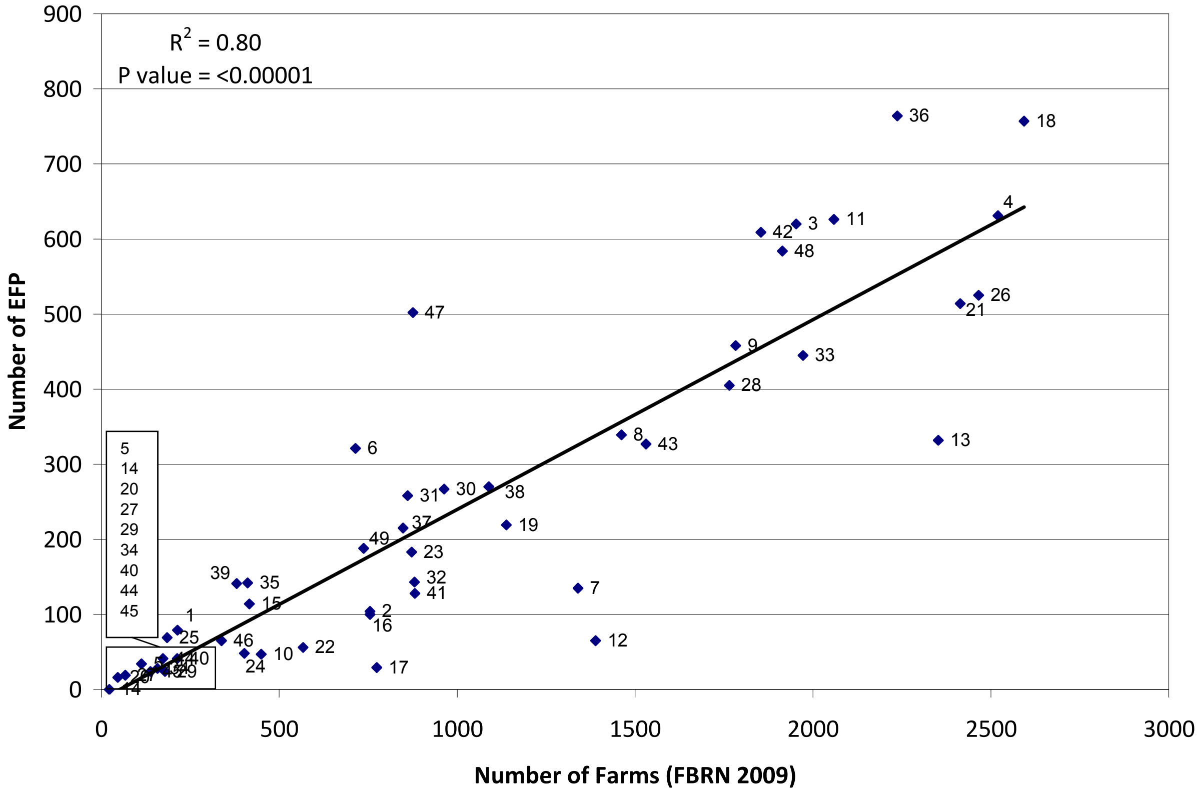

Figure 1: Number of peer reviewed and deemed appropriate EFPs against FBRNs (2009) by municipality (Refer to Table 2 – Appendix II for numerical key to municipality name)

4.1.2 Net Farm Income

Figure 2 shows the comparison of the total net farm income for the entire municipality and the number of nutrient management BMPs being adopted. This graph shows that Huron, Middlesex, Oxford, Perth and Wellington counties are the municipalities with the highest aggregated net farm income. Huron, Middlesex and Perth counties are also among the top five municipalities with the highest number of nutrient management BMPs adopted. The R-squared value for the regression analysis is 0.71 (P value: <0.00001) which indicates that there is a relatively good correlation.

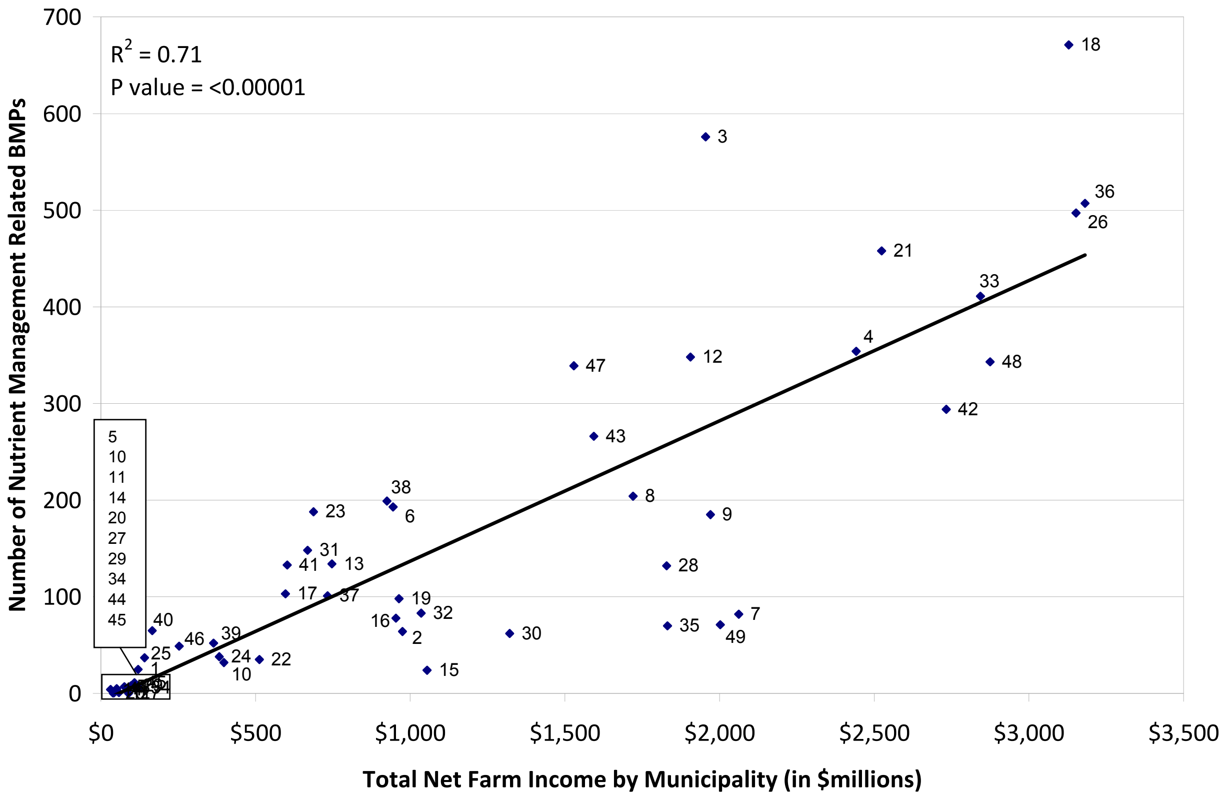

Figure 2: Total net farm income by municipality (in $millions) and number of nutrient management BMPs adopted during COFSP (April 2005-March 2010) (Refer to Table 2 – Appendix II for numerical key to municipality name)

4.1.3 Nutrient Management BMPs Adopted by Commodity Type

Figure 3 shows the total number of nutrient management BMPs that were adopted by each commodity type during COFSP (April 2005 to March 2010). Dairy producers adopted the most number of nutrient management BMPs (25% of projects), with field crops (20%) and beef (cow calf) (16%) following closely behind. There are fewer dairy farms in Ontario when compared to beef or field crop producers. Dairy has the highest value of market receipts in Ontario (OMAFRA, 2009). This could mean that these producers may have more income to spend on BMP projects. Oilseed and grain producers, which comprise the majority of field crop producers in Ontario, represent the majority of producers in Ontario (23% according to the 2006 Census of Agriculture). Commodity types like goats and sheep have few projects being adopted, most likely due to the small number of producers in these commodities when compared to the larger number of other livestock and field crop producers. When focusing on either livestock or crop nutrient management BMPs in Figure 4, the majority of livestock nutrient management BMPs are being adopted by the dairy sector and the majority of crop BMPs are being adopted by the field crop sector. Those practices that are applicable to both livestock and crop producers are counted in both the livestock and crop categories so will not add to the total BMP projects.

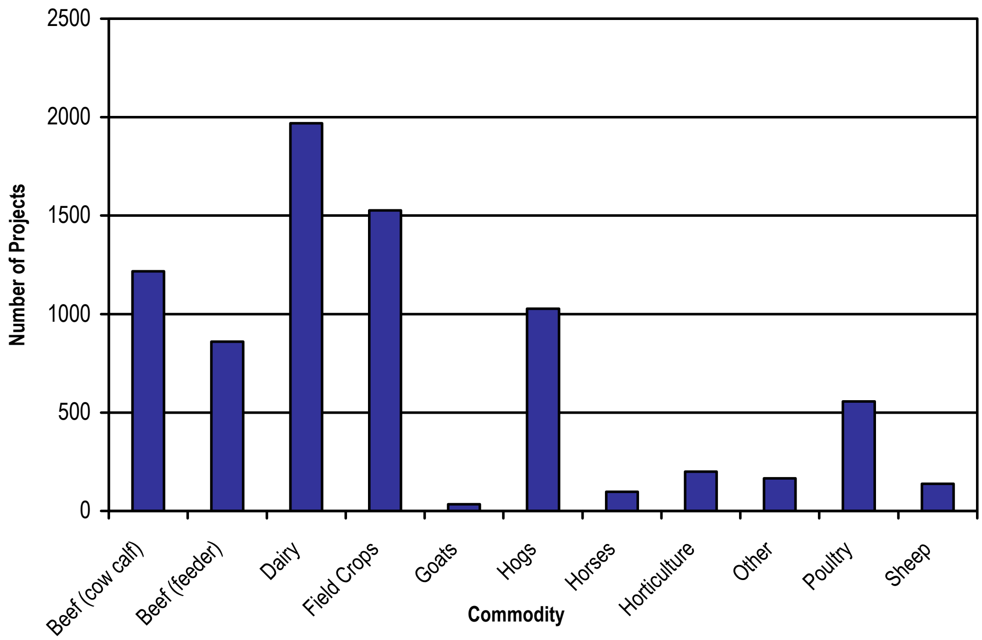

Figure 3: Number of combined nutrient management BMPs adopted during COFSP (April 2005-March 2010) by commodity

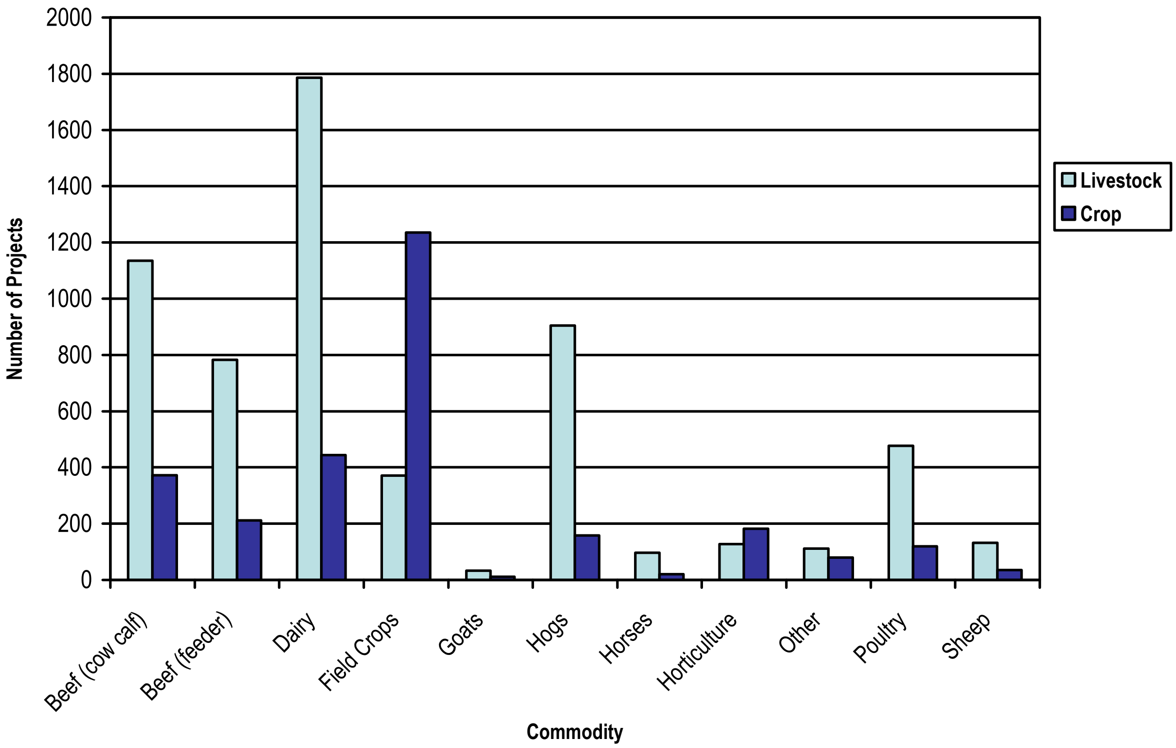

Figure 4: Number of livestock and crop nutrient management BMPs adopted during COFSP (April 2005-March 2010) by commodity
(Some practices are counted in both the livestock and crop categories)

Table 1 shows the most commonly adopted BMP projects by commodity. This illustrates the key BMPs adopted for the risks in each commodity's production system. These choices are guided by the EFP workbook questions.

Table 1: Top three most commonly adopted BMP project types by different agricultural commodity.

	1st Most Prevalent NM BMP			2nd Most Prevalent NM BMP			3rd Most Prevalent NM BMP		
Commodity	*BMP Practice Code**	*# of projects*	*% of all projects adopted by that commodity*	*BMP Practice Code*	*# of projects*	*% of all projects adopted by that commodity*	*BMP Practice Code*	*# of projects*	*% of all projects adopted by that commodity*
Beef – cow calf	**0501**	291	23.9%	**1003**	197	16.2%	**1001**	112	9.2%
Beef-feeders	**0104**	167	19.4%	**2401**	148	17.2%	**0501/0502**	134 for both Practice Codes	15.6%
Dairy	**2401**	460	23.4%	**0101**	390	19.8%	**0501**	228	11.6%
Field Crops	**1301 (1403 in APF)**	1155	75.6%	**0501**	73	4.8%	**2401**	66	4.3%
Goats	**0501**	9	26.5%	**2401**	9	26.5%	**0104**	6	17.6%
Hogs	**2401**	311	30.3%	**0301**	167	16.3%	**0101**	156	15.2%
Horses	**1003**	20	20.4%	**0501**	19	19.4%	**0104/2401**	16 for both Practice Codes	16.3%
Horticulture	**1701**	82	41.0%	**1301 (1403 in APF)**	73	36.5%	**0501**	24	12.0%
Other	**1301 (1403 in APF)**	53	31.9%	**2401**	19	11.4%	**0104**	15	9.0%
Poultry	**2401**	136	28.5%	**0104**	133	27.9%	**0101/0104**	47 for both Practice Codes	9.9%
Sheep	**0501**	29	21.0%	**1003**	29	18.8%	**2401**	17	12.3%

* see Appendix I, Table 3 for practice code descriptions

4.2 Nutrient Management BMP Adoption

4.2.1 Number of Nutrient Management BMPs Adopted by Municipality

The number of all nutrient management BMPs adopted during the five year study period per square kilometer of farmland in each municipality during the study period is depicted in Figure 5. The highest number of BMPs adopted is in southwestern Ontario, with the highest concentration in Waterloo region and Perth, Dufferin, Oxford, Bruce and Huron counties. There is a smaller number of BMPs adopted in northern and central Ontario corresponding with the smaller number of farms in these regions.

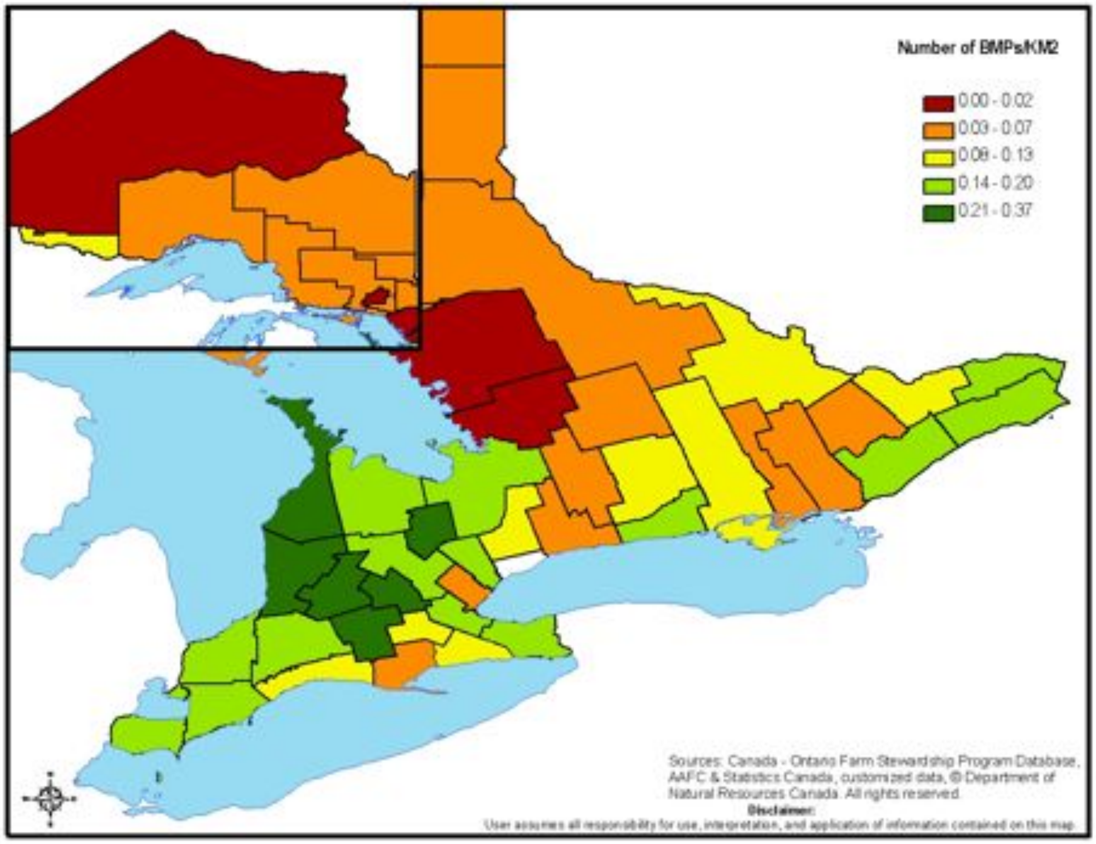

Figure 5: Number of nutrient management BMPs per square kilometre of farm area adopted during COFSP (April 2005-March 2010) by municipality

4.2.2 Livestock Nutrient Management BMP Adoption

The greatest adoption of livestock nutrient management BMPs occurred in municipalities for which the highest levels of manure production was calculated (Figure 6). The four municipalities with the highest manure production per hectare of farmland, Waterloo, Perth, Oxford and Wellington counties, had a high number (>290) of livestock nutrient management projects adopted by municipality. In Huron, Bruce and Grey counties, less manure per hectare was produced, but there is still a high number of livestock nutrient management projects adopted. Statistically, the relationship between livestock nutrient management BMP adoption and the total amount (kg) of manure produced by municipality was highly correlated (R^2 0.91; P value: < 0.00001). There was a medium to high (6,001-8,500 kg) amount of manure being produced per hectare of farmland in Halton and Peel regions, but there was a lower number of BMPs adopted. These two municipalities are located in the Greater Toronto Area (GTA) and have fewer farms, meaning fewer producers to adopt BMPs. Also, a large percentage of land in these two municipalities (47% for Peel and 46% for Halton) is rented or leased instead of owned by the producer. It has been shown that producers who rent land do not have an incentive to invest in long-term management for soil conservation of the land (Fraser, 2002). Since COFSP caps the amount of cost share for BMPs ($50,000 for APF and $30,000 for GF) to any one FBRN, producers who rent land might direct cost-share money towards projects on their owned property, which may be in a different municipality, instead of land that they rent or lease. Near-urban agriculture is known to have unique characteristics compared to predominantly agricultural rural areas. These characteristics include lower numbers of livestock, lower land ownership, and higher amounts of rented land (Heimlich and Barnard, 1992).

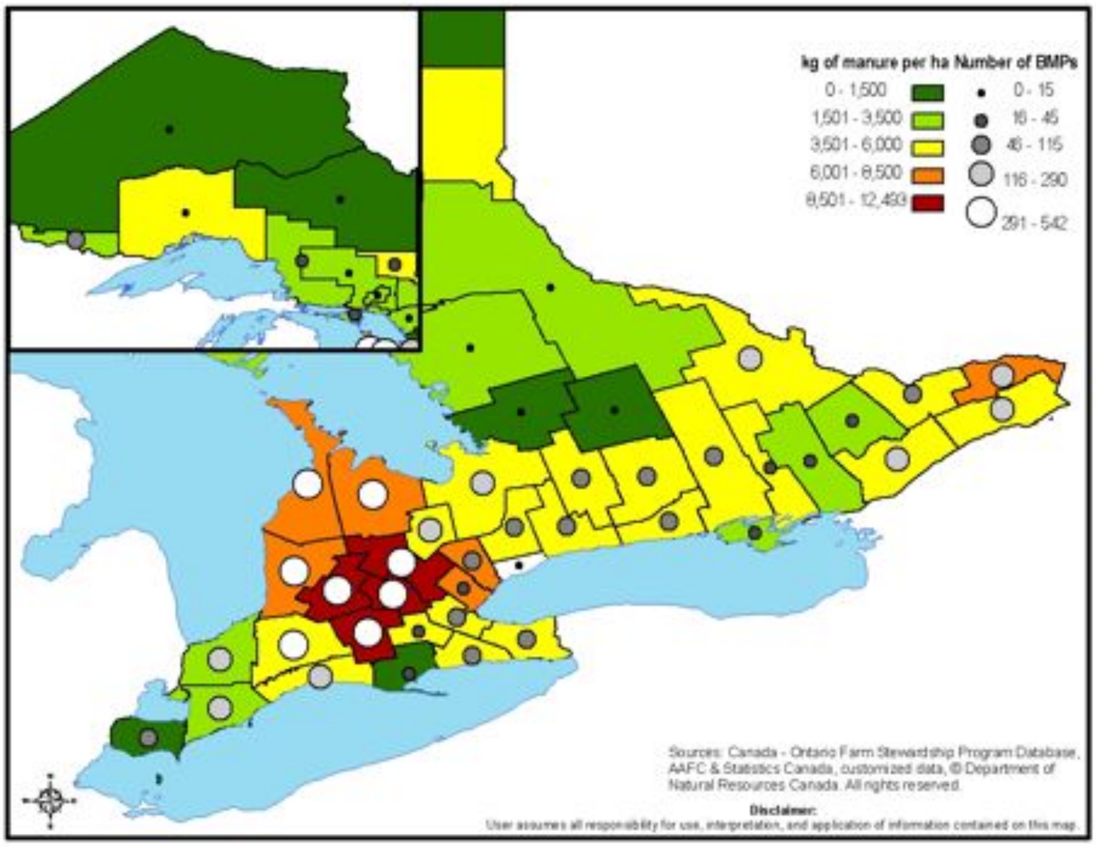

Figure 6: Comparison of manure produced in 2006 per hectare of farmland and the number of livestock nutrient management BMPs adopted during COFSP (April 2005-March 2010) by municipality

In areas where there were high levels of phosphorus generated from manure production per hectare of farmland, there was a higher level of adoption of livestock nutrient management BMPs compared to areas with lower levels of phosphorus produced from manure production (Figure 7), except for Halton and Peel regions. A high number (greater than 290 number of livestock nutrient management BMPs was adopted in Perth, Waterloo, Oxford, Bruce, Huron and Wellington counties for a total of 2399 practices. A medium to high (8.01-11.00 kg/ha) amount of phosphorus from manure are produced in the Hamilton and Niagara regional municipalities, but lower numbers of livestock nutrient management BMPs were adopted in these regions. Hamilton, like Halton and Peel is near the GTA and has a small farm area and few farmers, as well as a high percentage of rented land (43%). About 25% of Niagara region's livestock industry consists of poultry operations. Poultry manure is often not land-applied on farms in

Niagara and large shipments of poultry manure are typically sold and transported out of the region (van Bochove et al., 2010). This could explain the lower number of livestock nutrient management BMPs in this municipality.

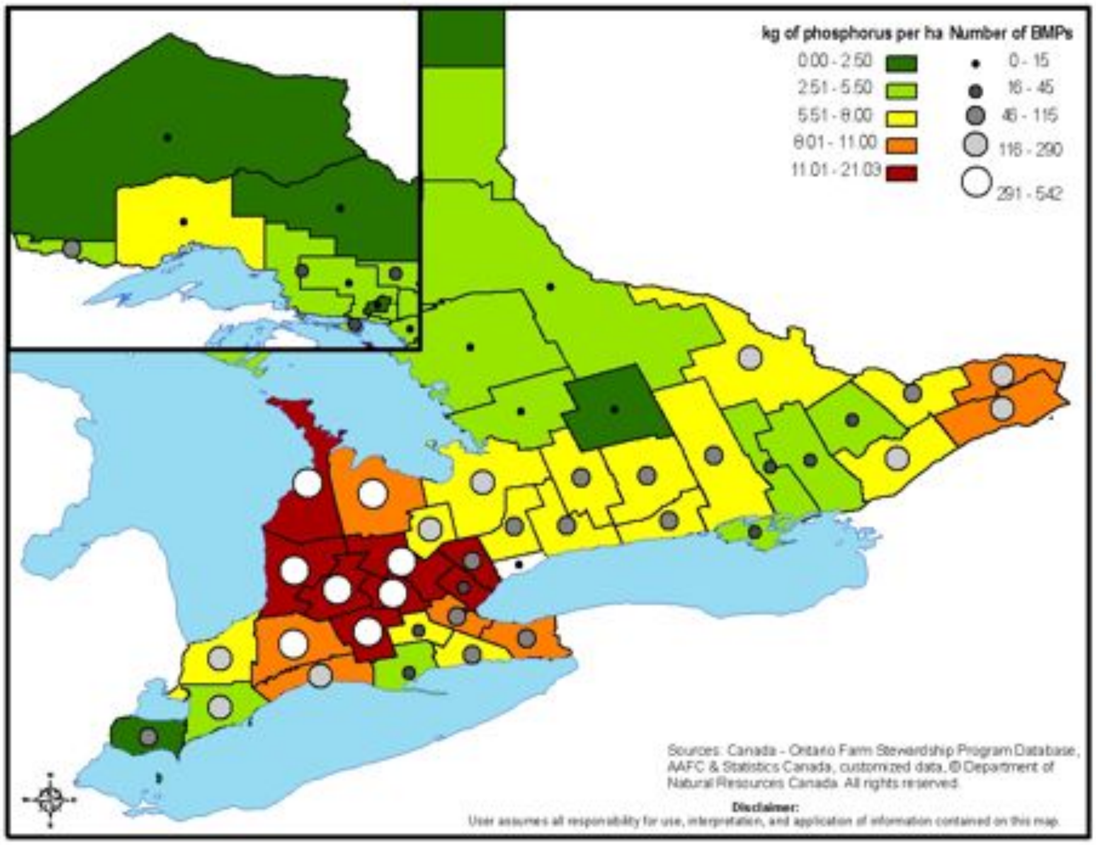

Figure 7: Comparison of phosphorus produced from manure in 2006 per hectare of farmland and number of livestock nutrient management BMPs adopted during COFSP (April 2005-March 2010) by municipality

In addition to the mapping analysis, a regression analysis was conducted to determine how well livestock nutrient management BMPs were correlated to the total amount of phosphorus produced from manure. Statistically, the relationship between livestock nutrient management BMPs and the total amount of phosphorus produced from manure by municipality is highly correlated (R^2 0.92; P value: <0.00001) (Figure 8). When the data are not normalized for farm area, the three municipalities (Huron, Bruce and Perth) that had adopted the highest number of livestock nutrient management BMPs during the study period are also the three municipalities with the greatest amount of phosphorus produced from manure per year. This was also true for nitrogen (graph not shown – R^2 0.91; P value: <0.00001). Though Peel and Halton regions had a high amount of phosphorus per hectare of farmland, there was actually a small amount of phosphorus produced in these regions. As discussed previously, this could be attributed to the small number of farmers and high percentage of rented land in these two regions and the phenomenon of the unique influences on near-urban agriculture.

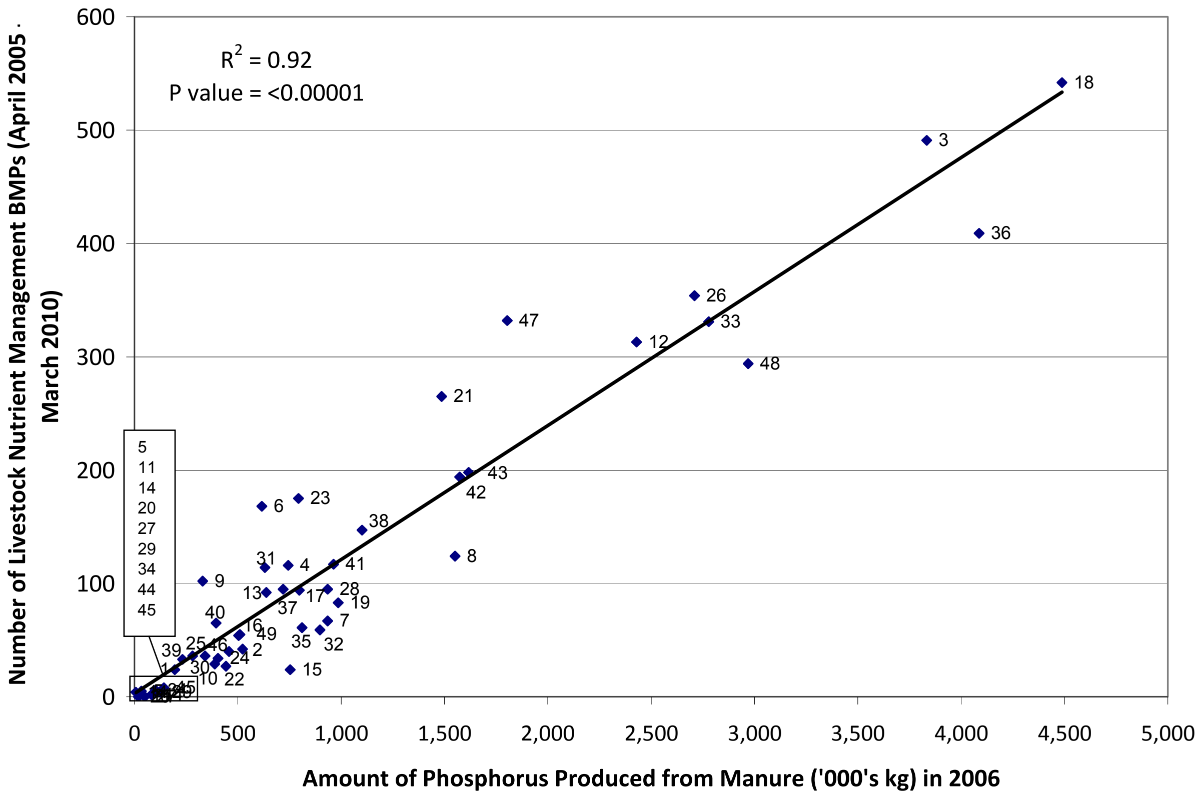

Figure 8: Number of livestock nutrient management BMPs adopted during COFSP by amount of phosphorus produced from manure ('000s kg) in 2006 (April 2005-March 2010) by municipality (Refer to Table 2 – Appendix II for numerical key to municipality name)

4.2.3 Crop Nutrient Management BMP Adoption

The comparison of the acreage of commercial fertilizer applied according to the 2006 Census of Agriculture and the number of crop nutrient management BMPs adopted by municipality is depicted in Figure 9. The municipalities where the largest area of farmland received commercial fertilizer were also the municipalities with the highest number of crop nutrient management BMPs adopted. These municipalities are the region of Chatham-Kent, and Huron, Lambton and Middlesex counties. A large number (192) of crop nutrient BMPs were adopted in Bruce county even though the acreage fertilized was only moderately high (Figure 9). Chatham-Kent, Lambton, Middlesex and Huron are all in the top 5 municipalities in the province with the highest number of oilseed and grain producers. Statistically, Figure 10 shows the relationship between the area fertilized and crop nutrient management BMPs adopted is highly correlated (R^2 0.87; P value: <0.00001). This confirms the strong targeting of crop nutrient management BMPs to areas with the greatest potential for fertilizer nutrient risks.

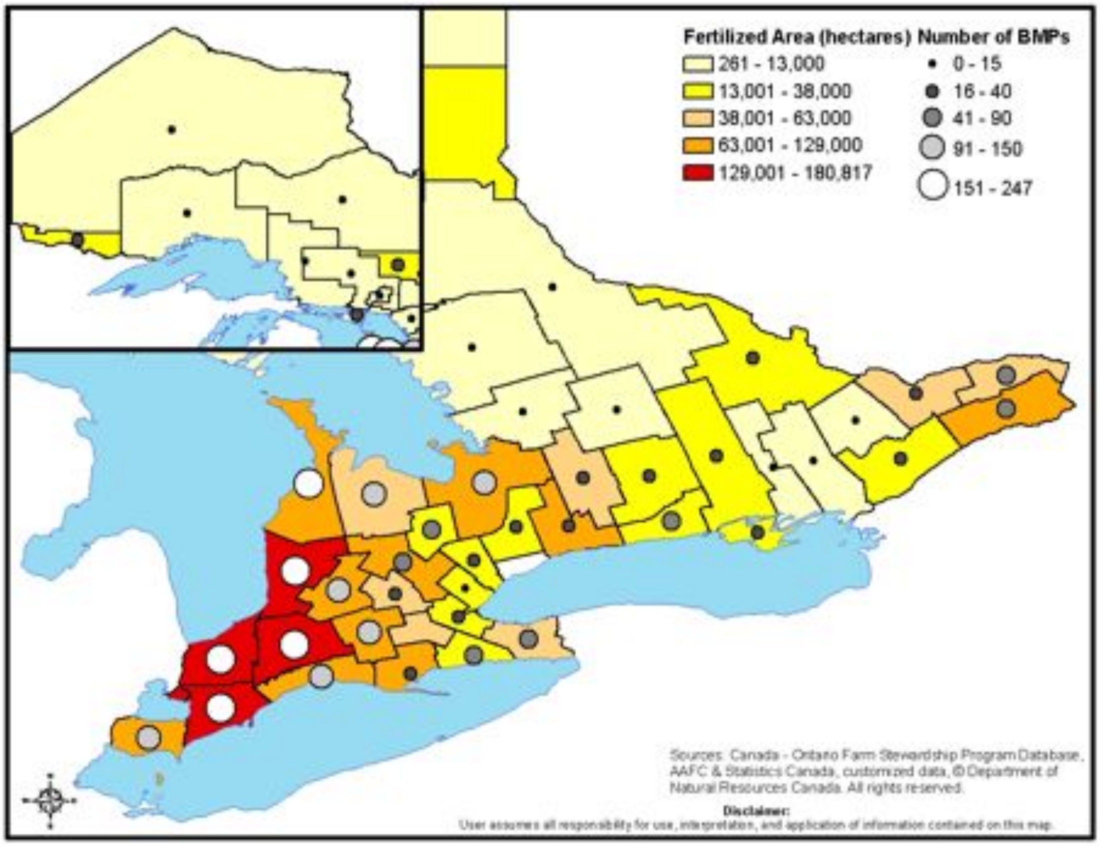

Figure 9: Comparison of the area of commercial fertilizer inputs in 2005 and the number of crop nutrient management BMPs adopted during COFSP (April 2005-March 2010) by municipality

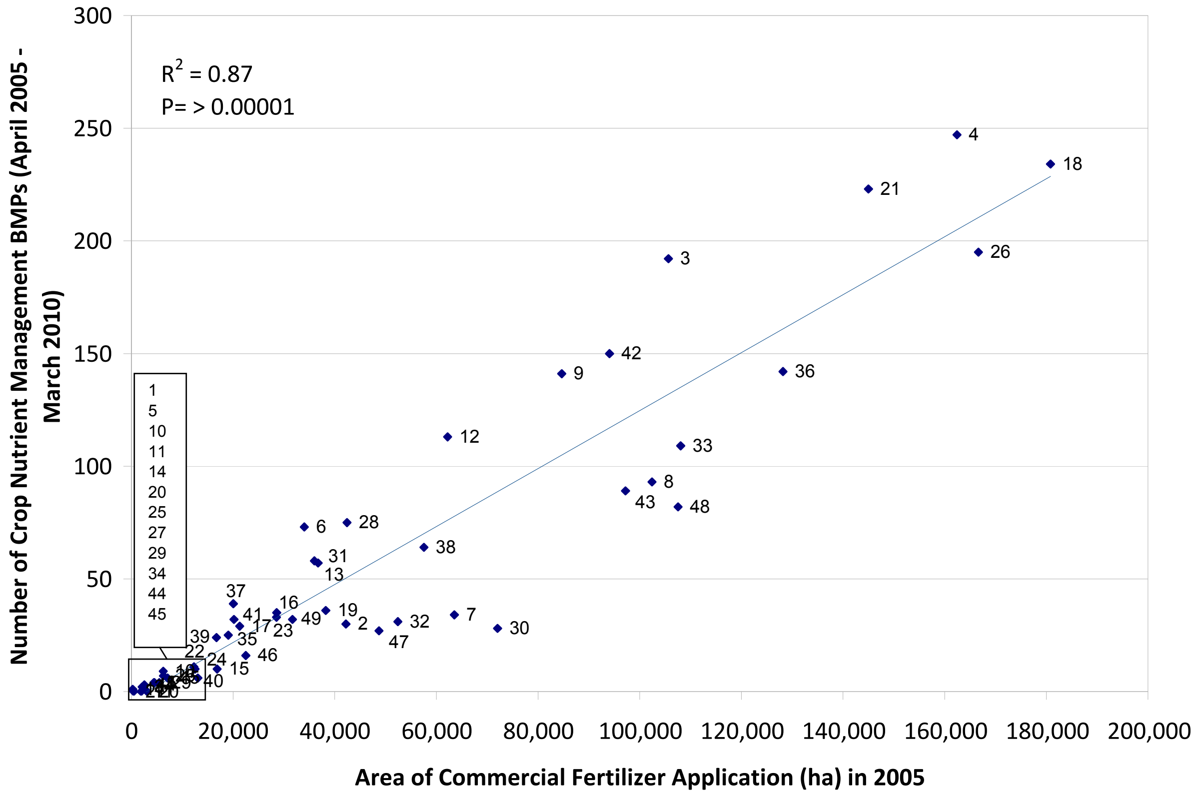

Figure 10: Number of crop nutrient management BMPs adopted during COFSP by area receiving commercial fertilizer inputs in 2005 (April 2005-March 2010) by municipality (Refer to Table 2 – Appendix II for numerical key to municipality name)

5.0 Conclusion

In conclusion, the Canada-Ontario Environmental Farm Plan is a successful educational tool to help producers assess areas at risk from agriculturally sourced nutrients, set priorities and target key issues. COFSP accelerates the adoption of BMPs by providing financial incentive to the producer. EFP and COFSP complement other drivers for adoption of BMPs and help influence behaviour by guiding producers to undertake priority actions for environmental performance improvement. Through educational programs like the EFP, cost-share opportunities like COFSP and the Lake Simcoe Farm Stewardship Program, regulations like the NMA, and peer pressure to constantly raise the bar amongst the agricultural community, producers are adopting BMPs that target areas or activities of risk on their landscape.

There is a high correlation between the number of nutrient management BMPs adopted across the province (whether crop or livestock related) and the areas where there may be increased risk of elevated nutrients in the environment (whether from fertilizer application or manure production). The relationship between the adoption of livestock nutrient management BMPs and the total amount (kg) of manure produced by municipality is highly correlated (R^2 0.91; P value: <0.00001). As would be expected, the relationship is similar for livestock BMP adoption and amount of phosphorus and nitrogen produced from manure. The relationship between the adoption of crop nutrient management BMPs and the acreage of commercial fertilizer applied to field crops is also highly correlated (R^2 0.87; P value: <0.00001).

There are areas where fewer BMPs are being adopted despite relatively large amounts of nutrients produced or applied to cropland. This phenomena tends to occur in regions with a high percentage of rented land (Halton and Peel regions) or where nutrients (in the form of manure) are exported out of the region, such as occurs where there is a large concentration of poultry operations (Niagara region), which has a relatively small land base.

The EFP provides an opportunity for the producer to become informed about nutrient management in the context of their own farm and the COFSP helps accelerate BMP adoption. While the EFP is a universally accessible program to farmers in Ontario, this report provides evidence that the implementation of the EFP in Ontario results in place-based, targeted action in the province on priority issues and areas. The EFP and COFSP help target the adoption of livestock and/or crop nutrient management BMPs on farms and in municipalities with the highest production of manure or use of fertilizer in the province.

6.0 References

Agriculture and Agri-Food Canada and Statistics Canada, customized tabulations, Census of Agriculture CGC Base 1996, 2001, 2006, Census of Agriculture Regular Base 1971, 1976, 1981, 1986, 1991

Bongiovanni R. and Lowenberg-Deboer, J. 2004. Precision Agriculture and Sustainability. Precision Agriculture. 5:359-387.

Cayley, J. and Toombs, M. 1997. Severn Sound Remedial Action Plan: Evaluation of a Vegetated Filter Strip (VFS) for Barnyard Runoff. For Presentation at NABEC-97 Northeast Agricultural and Biological Engineering Conference. American Society of Agricultural Engineers. College Park, Maryland.

Chadwick, D. and Chen, S. 2002. Manure. In: Haygarth, P., and Jarvis, S. Agriculture, hydrology, and water quality. United Kingdom: CABI Publishing. pp. 57-76.

Environment Canada. 2009. Eutrophication of water bodies. Available from: http://www.ec.gc.ca/soer-ree/English/SOER/1996Report/Doc/1-6-6-4-7-1.cfm

Fawecett, R. 2009. A Review of BMPs for Managing Crop Nutrients and Conservation Tillage to Improve Water Quality. The Conservation Technology Information Center. Available from: http://www.conservationinformation.org/?action=learningcenter_publications

Fraser, E.D.G. 2004. Land tenure and agricultural management: Soil conservation on rented and owned fields in southwest British Columbia. Agriculture and Human Values. 21: 73-79.

Goss, M., Rollins, K., McEwan, K., Shaw, J., and Lammers-Helps, H. 2002. *The Walkerton Inquiry: Commissioned Paper 6 - The Management of Manure in Ontario with Respect to Water Quality*. Toronto: Queen's Paper for Ontario.

Hatch, D., Goulding, K., and Murphy, D. 2002. Nitrogen. In: Haygarth, P., and Jarvis, S. Agriculture, hydrology, and water quality. United Kingdom: CABI Publishing. pp. 7-28.

Heimlich, R.E., and Barnard, C.H. 1992. Agricultural Adaptation to Urbanization: Farm Types in Northeast Metropolitan Areas. Northeastern Journal of Agricultural and Resource Economics. 21(1):50-60.

OMAFRA and Soil Resource Group. 2008. The Continued Development of a Comprehensive Risk Management Tool for On-Farm Management of Chemical and Pathogen Threats Associated with Agricultural Field and Farmstead Activities. Guelph: Ontario Ministry of Agriculture, Food and Rural Affairs. pp. 399.

Ontario Ministry of Agriculture, Food and Rural Affairs, and the Ontario Ministry of Environment. 2005. Best Management Practices – Manure Management. Guelph: Ontario Ministry of Agriculture, Food and Rural Affairs. pp. 140.

Ontario Ministry of Agriculture, Food and Rural Affairs. 2006. Best Management Practices – Nutrient Management Planning. Guelph: Ontario Ministry of Agriculture, Food and Rural Affairs. pp. 114.

Ontario Ministry of Agriculture, Food and Rural Affairs. 2009. Statistical Summary of Ontario Agriculture. Available from: http://www.omafra.gov.on.ca/english/stats/agriculture_summary.htm

Ontario Ministry of Agriculture, Food and Rural Affairs. 2011. Starting a Farm in Ontario - Business Information Bundle for New Farmers. Available from: http://www.omafra.gov.on.ca/english/busdev/newentrant/sec8.htm.

Schmalz, C. and Brown, S. 2008. Spatial Analysis of Best Management Practices Implements through Cost Share Programs associated with the Canada Ontario Environmental Farm Plan (EFP) April 2005 – March 31, 2008. Guelph: Ontario Soil and Crop Improvement Association and Agriculture and Agri-Food Canada. pp. 128.

United States Department of Agriculture, Natural Resources Conservation Service. 2011. Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Great Lakes Region. Final Draft. http://www.nrcs.usda.gov/technical/nri/ceap/

Van Bochove, E. Denault, J.T., Leclerc, M.L., Thériault, G. Dechmi, F., Allaire, S.E., Rousseau, A.N., and Drury, C.F. 2011. Temporal trends of risk of water contamination by phosphorus from agricultural land in the Great Lakes Watersheds of Canada**.** Canadian Journal of Soil Science. 91: 1-11.

Appendix I

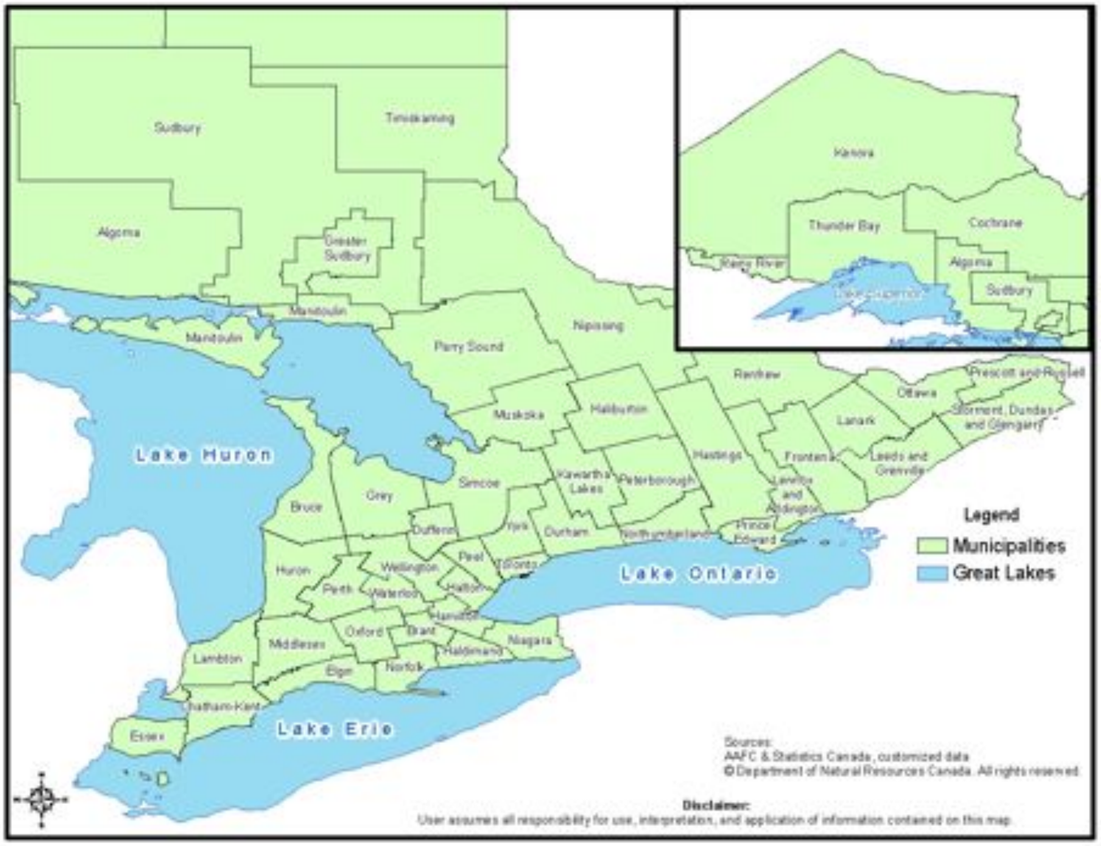

Figure 11: Map of Ontario Municipalities

Table 2: Key to Municipal Numeric Code used for Report Figures

Municipality Name	Reference Number for Graphs	Municipality Name	Reference Number for Graphs
Algoma	1	Middlesex	26
Brant	2	Muskoka	27
Bruce	3	Niagara	28
Chatham-Kent	4	Nipissing	29
Cochrane	5	Norfolk	30
Dufferin	6	Northumberland	31
Durham	7	Ottawa	32
Elgin	8	Oxford	33
Essex	9	Parry Sound	34
Frontenac	10	Peel	35
Greater Sudbury	11	Perth	36
Grey	12	Peterborough	37
Haldimand	13	Prescott and Russell	38
Haliburton	14	Prince Edward	39
Halton	15	Rainy River	40
Hamilton	16	Renfrew	41
Hastings	17	Simcoe	42
Huron	18	Stormont, Dundas and Glengarry	43
Kawartha lakes	19	Sudbury	44
Kenora	20	Thunder Bay	45
Lambton	21	Timiskaming	46
Lanark	22	Waterloo	47
Leeds and Grenville	23	Wellington	48
Lennox and Addington	24	York	49
Manitoulin	25		

Table 3: List of COFSP Nutrient Management Related Practice Codes used during Analysis

Category Code	Best Management Practice Category	Practice Code	Type of Practice	Production System
01	**Improved Manure Storage and Handling**	0101	Increased storage to meet winter spreading restrictions (including satellite storage)	Livestock
		0102	Improved features to prevent risks of water contamination (leaks, spills)	Livestock
		0103	Slurry storage covers to reduce odours and GHG emissions and liquid volume	Livestock
		0104	Containment systems for solid manure (includes covers)	Livestock
		0105	Assessment and monitoring of existing manure storage infrastructure	Livestock
		0106	Engineering design work (n/a in GF)	Livestock
02	**Manure Treatment**	0201	Dewatering systems, nutrient recovery systems	Livestock
		0202	Composting of manure	Livestock
		0203	Anaerobic digester systems	Livestock
		0204	Engineering design work (n/a in GF)	Livestock
03	**Manure Land Application**	0301	Specialization modifications to equipment for improved manure application	Livestock
04	**In Barn Improvements for Water Efficiency**	0401	More efficient livestock watering devices and cleanout systems to reduce water use and decrease manure volumes	Livestock
		0402	Engineering design work (n/a in GF)	Livestock
05	**Farmyard and Horticultural Facilities Runoff Control**	0501	Upstream diversion around existing farmyards, existing greenhouse and container nursery operations; includes downstream protection (e.g. catch basins, storage for runoff, constructed wetlands)	Crop/Livestock
		0502	Construction of impermeable base and/or roof for minimizing runoff from livestock pen areas and confinement areas	Livestock
		0503	Engineering design work (n/a in GF)	Crop/Livestock
06	**Relocation of Livestock Confinement and Horticultural Facilities from Riparian Areas**	0601	Relocation of livestock confinement facilities such as barns, corrals, paddocks and wintering sites away from riparian and other very environmentally sensitive areas with equivalent facilities at a more suitable location	Livestock

		0602	Relocation of horticultural facilities such as greenhouses and container nurseries from riparian and other very environmentally sensitive areas	Crop
		0603	Engineering design work (n/a in GF)	Crop/Livestock
07	**Wintering Site Pasture Management**	0701	Shelterbelt establishment	Livestock
		0702	Portable shelters, constructed wind screens and natural windbreaks	Livestock
		0703	Alternative watering systems	Livestock
		0704	Field access improvements for wintering site pasture management	Livestock
		0705	Fence modifications to the improved wintering site	Livestock
10	**Upland and Riparian Area Habitat Management**	1001	Alternative watering system to manage livestock: gravity fed, solar, wind or grid power, pump and waterline systems	Livestock
		1003	Fencing to improve grazing systems	Livestock
		1005	Grazing management: cross fencing to relieve grazing pressure on riparian systems	Livestock
13	**Precision Agriculture**	1301 (1403 in APF)	Precision farming applications: Global Positioning Systems (GPS)	Crop
17	**Nutrient Recovery from Waste Water**	1701	Recycling of wastewater streams from existing milk houses, fruit and vegetable washing facilities and greenhouses to recover nutrients	Crop/Livestock
		1702	Engineering design work (n/a in GF)	Crop/Livestock
24	**Resource Planning**	2401	Consultative services to develop nutrient management plans; planning and decision support tools	Livestock
		2409	Crop Nutrient Planning – Consultative Services to develop crop nutrient plan (n/a in APF)	Crop
		2403 (2601 in APF)	Consultative services to develop range and grazing management plans	Livestock

Tables 4 to 8: Most Commonly Adopted COFSP Nutrient Management Practice Codes

based on COFSP data from April 2005 to March 2010

	Table 4 – Increased storage to meet winter spreading restrictions (include satellite storage) (0101)		
	Municipality	***Watershed***	***Commodity***
1	Perth	Grand River	Dairy
	63	109	389
2	Middlesex	Upper Thames	Hogs
	59	98	157
3	Oxford	South Nation	Poultry
	57	66	48
4	Huron	Ausable Bayfield	Beef (feeder)
	45	54	43
5	Lambton	Maitland Valley	Field Crops
	45	51	19
6	Wellington	St. Clair	Beef (cow calf)
	43	45	17
7	Waterloo	Saugeen	Other
	38	45	10
8	Prescott and Russell	Lower Thames	Horticulture
	38	33	2
9	Bruce	Long Point	Sheep
	37	23	1
10	SDG	Grey Sauble	Horses
	34	15	1

	Table 5 – Containment Systems for solid manure (includes covers) (0104)		
	Municipality	***Watershed***	***Commodity***
1	Huron	Grand River	Dairy
	92	178	193
2	Waterloo	Maitland Valley	Beef (feeder)
	88	89	167
3	Bruce	Saugeen	Poultry
	64	75	135
4	Wellington	Upper Thames	Beef (cow calf)
	55	56	106
5	Perth	Ausable Bayfield	Hogs
	53	46	58
6	Middlesex	St. Clair	Field Crops
	47	37	24
7	Grey	Nottawasaga Valley	Horses
	46	31	16
8	Oxford	Grey Sauble	Other
	36	30	15
9	Lambton	Lower Thames	Sheep
	28	21	9
10	Dufferin	Niagara	Goats
	28	21	6

	Table 6 – Upstream diversion around existing farm-yards, existing greenhouse and container nursery operations (0501)		
	Municipality	***Watershed***	***Commodity***
1	Huron	Saugeen	Beef (cow calf)
	103	117	291
2	Bruce	Maitland Valley	Dairy
	99	91	229
3	Grey	Grand River	Beef (feeder)
	78	85	134
4	Middlesex	Nottawasaga Valley	Field Crops
	49	57	73
5	Dufferin	Ausable Bayfield	Poultry
	46	56	40
6	Simcoe	Grey Sauble	Hogs
	44	50	34
7	Perth	Upper Thames	Sheep
	38	48	29
8	Peterborough	St. Clair	Horticulture
	33	37	24
9	Lambton	Otonabee	Horses
	29	33	20
10	Wellington	Lake Simcoe	Other
	29	29	13

* Municipality and Watershed (Watershed refers to Conservation Authority boundary) as identified on Project Proposal Application and Commodity (primary commodity type of farm) as identified on Program Enrollment form

	Table 7 - Nutrient Management Planning (2401)		
	Municipality	***Watershed***	***Commodity***
1	Perth	Grand River	Dairy
	148	219	460
2	Huron	Upper Thames	Hogs
	143	198	323
3	Oxford	Maitland Valley	Beef (feeder)
	120	159	149
4	Middlesex	Saugeen	Poultry
	90	98	137
5	Waterloo	Ausable Bayfield	Beef (cow calf)
	87	97	78
6	Bruce	South Nation	Field Crops
	82	89	63
7	Wellington	St. Clair	Other
	79	78	19
8	Lambton	Lower Thames	Sheep
	71	40	17
9	SDG	Long Point	Horses
	59	36	16
10	Prescott and Russell	Nottawasaga Valley	Goats
	35	24	9

	Table 8 – Precision farming applications: GPS (1403/ 1301 in APF)		
	Municipality	***Watershed***	***Commodity***
1	Chatham-Kent	Lower Thames	Field Crops
	238	258	1142
2	Lambton	St. Clair	Dairy
	193	245	183
3	Middlesex	Upper Thames	Hogs
	142	168	126
4	Huron	Grand River	Beef (cow calf)
	129	125	81
5	Simcoe	Ausable Bayfield	Poultry
	100	115	78
6	Perth	Maitland Valley	Beef (feeder)
	98	111	77
7	Bruce	Saugeen	Horticulture
	85	98	73
8	Essex	South Nation	Other
	83	91	54
9	Oxford	Essex	Sheep
	80	79	6
10	Elgin	Nottawasaga Valley	Horses
	80	75	1

* Municipality and Watershed (Watershed refers to Conservation Authority boundary) as identified on Project Proposal Application and Commodity (primary commodity type of farm) as identified on Program Enrollment form

Table 9: Manure and Nutrient Coefficients

Variable	Average animal weight (kg)	Manure (kg/year)	Nitrogen (kg/year)	Phosphorus (kg/year)
Beef Cows	635	13,444	78.8	21.3
Horses and ponies	450	8,377	49.3	11.7
Sheep and lambs	45	662	7.0	1.4
Goats	64	958	10.5	2.6
Bulls	726	15,364	90.1	24.4
Calves	204	4,321	25.3	6.9
Heifers	421	8,904	52.2	14.1
Dairy cows	612	22,706	122.0	26.8
Boars	159	1,358	9.9	3.3
Growing and finishing pigs	61	1,287	8.5	3.2
Nursing and weaner pigs	11	613	3.5	1.4
Sows and gilts	125	1,358	9.6	3.1
Steers	454	9,603	56.3	15.2
Broilers, roasters and Cornish hens	0.9	28	0.36	0.09
Laying hens	1.8	42	0.55	0.19
Pullets	0.9	28	0.36	0.090
Turkeys	6.8	117	1.54	0.57

Source: “A Geographical Profile of Manure Production in Canada, 2001” (Statistics Canada, 2006)

Tables 10 to 13: Top 10 Municipalities, Watersheds and Commodity Types Adopting BMP Projects and Number of Projects Adopted

based on COFSP Data April 2005 to March 2010

	Table 10 – Nutrient Management Related BMPs		
	Municipality	***Watershed***	***Commodity***
1	Huron	Grand River	Dairy
	671	981	1969
2	Bruce	Upper Thames	Field Crops
	576	727	1527
3	Perth	Maitland Valley	Beef (cow calf)
	507	659	1216
4	Middlesex	Saugeen	Hogs
	497	650	1027
5	Lambton	St. Clair	Beef (feeder)
	458	549	860
6	Oxford	Ausable Bayfield	Poultry
	411	474	556
7	Chatham-Kent	Lower Thames	Horticulture
	354	470	200
8	Grey	South Nation	Other
	348	388	166
9	Wellington	Nottawasaga Valley	Sheep
	343	275	138
10	Waterloo	Grey Sauble	Horses
	339	244	98

	Table 11 – Livestock Nutrient Management Related BMPs		
	Municipality	***Watershed***	***Commodity***
1	Huron	Grand River	Dairy
	542	856	1786
2	Bruce	Upper Thames	Beef (cow calf)
	491	559	1135
3	Perth	Saugeen	Hogs
	409	552	904
4	Middlesex	Maitland Valley	Beef (feeder)
	354	548	783
5	Waterloo	Ausable Bayfield	Poultry
	332	359	477
6	Oxford	St. Clair	Field Crops
	331	303	371
7	Grey	South Nation	Sheep
	313	297	132
8	Wellington	Grey Sauble	Horticulture
	294	225	127
9	Lambton	Lower Thames	Other
	265	212	112
10	SDG	Nottawasaga Valley	Horses
	198	200	97

	Table 12 – Crop Nutrient Management Related BMPs		
	Municipality	***Watershed***	***Commodity***
1	Chatham-Kent	St. Clair	Field Crops
	247	285	1235
2	Huron	Lower Thames	Dairy
	234	282	444
3	Lambton	Upper Thames	Beef (cow calf)
	223	224	372
4	Middlesex	Grand River	Beef (feeder)
	195	223	212
5	Bruce	Saugeen	Horticulture
	192	220	182
6	Simcoe	Maitland Valley	Hogs
	150	205	158
7	Perth	Ausable Bayfield	Poultry
	142	172	120
8	Essex	Essex	Other
	141	136	80
9	Grey	Nottawasaga Valley	Sheep
	113	136	35
10	Oxford	South Nation	Horses
	109	117	20

	Table 13– All Projects Adopted during COFSP (April 2005 to March 2010)		
	Municipality	***Watershed***	***Commodity***
1	Huron	Grand River	Field Crops
	1432	2014	5760
2	Chatham-Kent	Lower Thames	Dairy
	1272	1514	3341
3	Middlesex	Upper Thames	Beef (cow calf)
	1163	1496	2245
4	Bruce	Maitland Valley	Horticulture
	1074	1343	1840
5	Niagara	St. Clair	Hogs
	1039	1238	1618
6	Perth	Saugeen	Beef (feeder)
	999	1172	1426
7	Lambton	Niagara	Poultry
	968	1139	1048
8	Simcoe	Ausable Bayfield	Other
	852	1048	817
9	Essex	South Nation	Sheep
	834	947	325
10	Wellington	Essex	Horses h
	735	796	204

* Municipality and Watershed (Watershed refers to Conservation Authority boundary) as identified on Project Proposal Application and Commodity (primary commodity type of farm) as identified on Program Enrollment form

Nutrient Management Related BMPs in Table 8 include all nutrient management BMPs whether they are livestock related, crop related, or both

Appendix II

Nutrient Management BMPs Adopted by Watershed

In Ontario, watersheds are managed by 36 Conservation Authorities (CAs) across the province. When applying for COFSP, producers will self-identify what CA they are situated in. During the 5-year study period, 7391 nutrient management projects were implemented in areas located within a CA boundary, while 400 of the projects did not fall into an organized CA watershed boundary. As discussed in the main report, Agriculture and Agri-Food Canada interpolates Statistics Canada's census data at a sub-sub drainage area (i.e., tertiary watershed) level (Figure 12), which differs from the level of organization (CA boundaries) that OSCIA records the BMP adoption (Figure 13). The boundaries of these two scales vary greatly; therefore no regression analysis was conducted to compare the relationships between manure production and fertilizer use with nutrient management BMP adoption by CA.

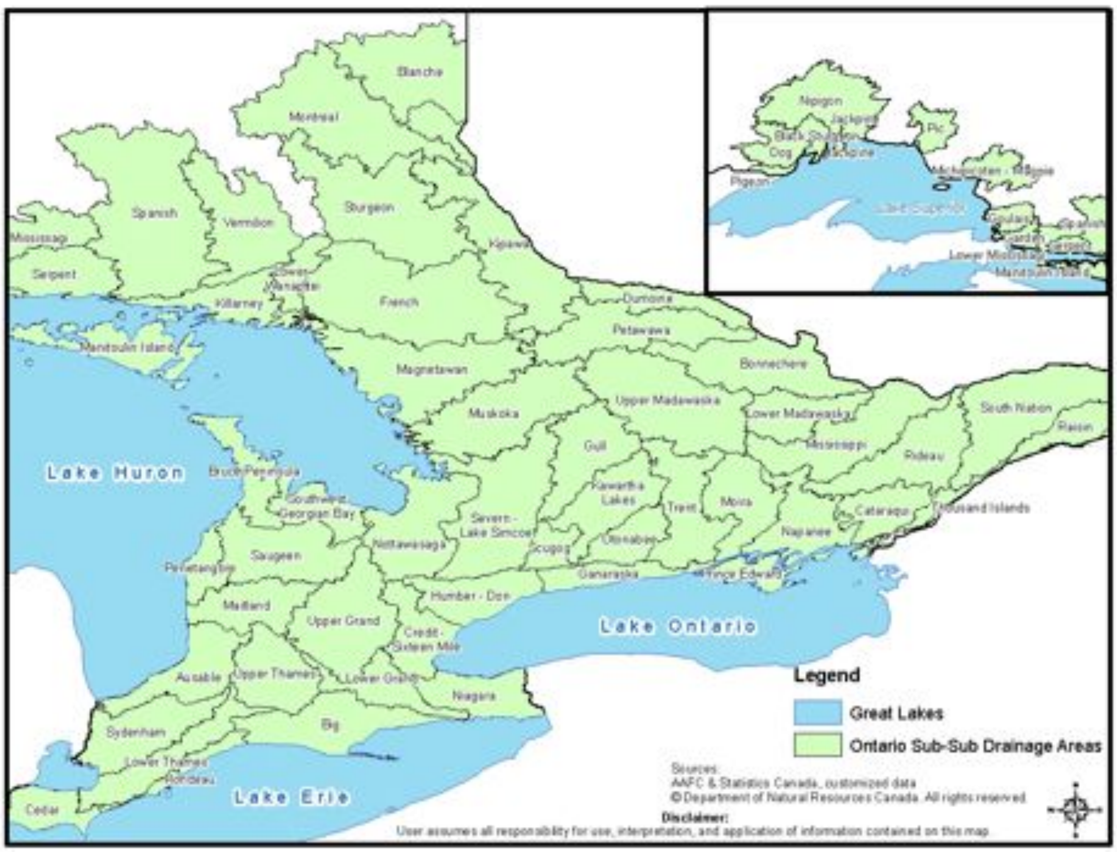

Figure 12: Map of Ontario Sub-Sub Drainage Areas (Tertiary Watersheds)

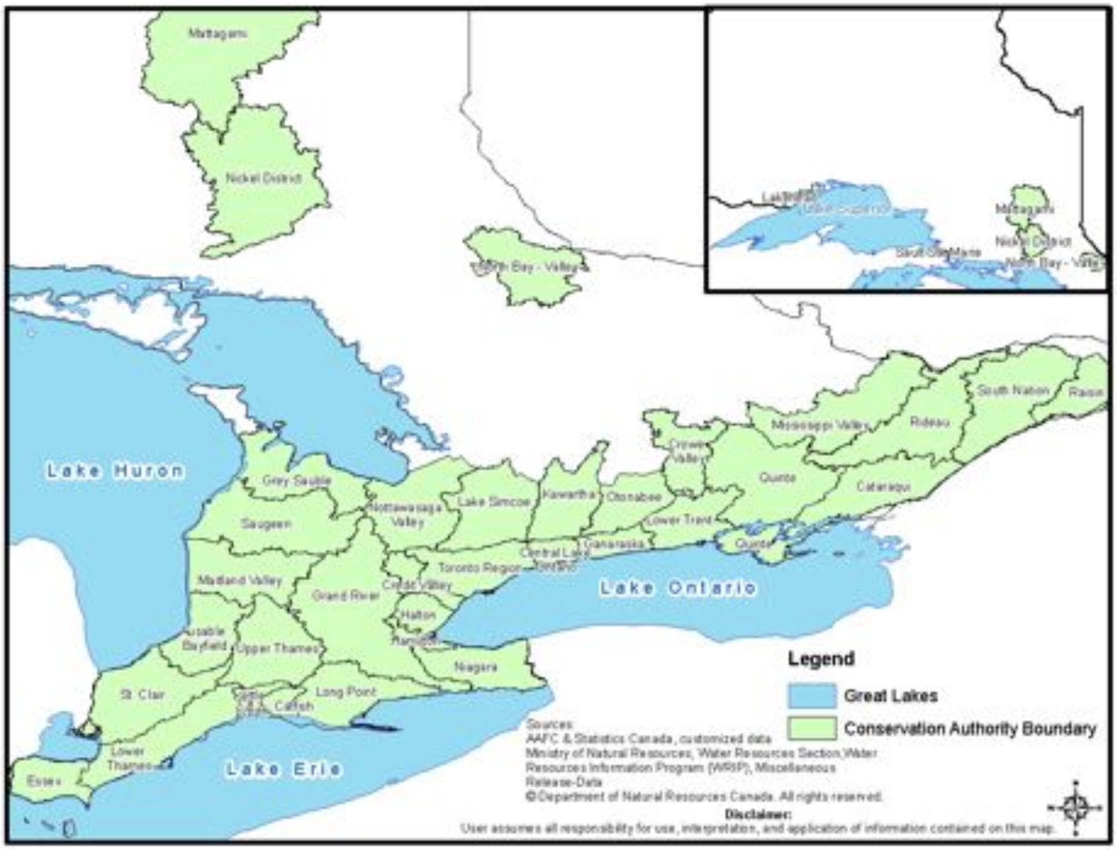

Figure 13: Map of Ontario Conservation Authorities

Distribution of Nutrient Management BMPs by Watershed

The distribution of nutrient management BMPs (Figure 14) is concentrated in western Ontario and most projects were adopted within the Saugeen, Maitland Valley, Grand River and Upper Thames watersheds. A large number of nutrient management projects were adopted in watersheds in southwestern Ontario with the exception of the Catfish and Kettle Creek watersheds which are part of the Big Creek sub-sub drainage area. These watersheds are small in geographical size and therefore may contain fewer producers and/or not have as many opportunities to adopt nutrient management BMPs. In the Saugeen, Maitland Valley, Grand River and Upper Thames watersheds rural water quality programs are delivered by the municipalities and conservation authorities to provide financial and technical assistance for producers in these watersheds who want to adopt BMPs which are complimentary to COFSP.

Producers in the Grand River watershed have access to additional cost-share funding through the Grand River Rural Water Quality Program, the Brant Rural Water Quality Program, the Wellington Rural Water Quality Program (WRWQP) and Clean Water Program (CWP). Producers in the Maitland Valley watershed can also access the WRWQP and CWP. The CWP is also available for producers in the Upper Thames, Ausable Bayfield, St. Clair, and Long Point watersheds. There is also the Huron Clean Water Project, which provides financial and technical assistance to producers who are located in Maitland Valley and Ausable Bayfield watersheds. There are many other additional cost-share programs available to producers in other watersheds. The key focus of many of these programs is nutrient management and protecting water resources. It should be noted that, as in the main report, BMP adoption by watershed as described in this Appendix only includes those BMP projects that have been implemented with COFSP funding, and does not include all of the above mentioned additional cost-share programs funded by various Ontario ministries and conservation authorities.

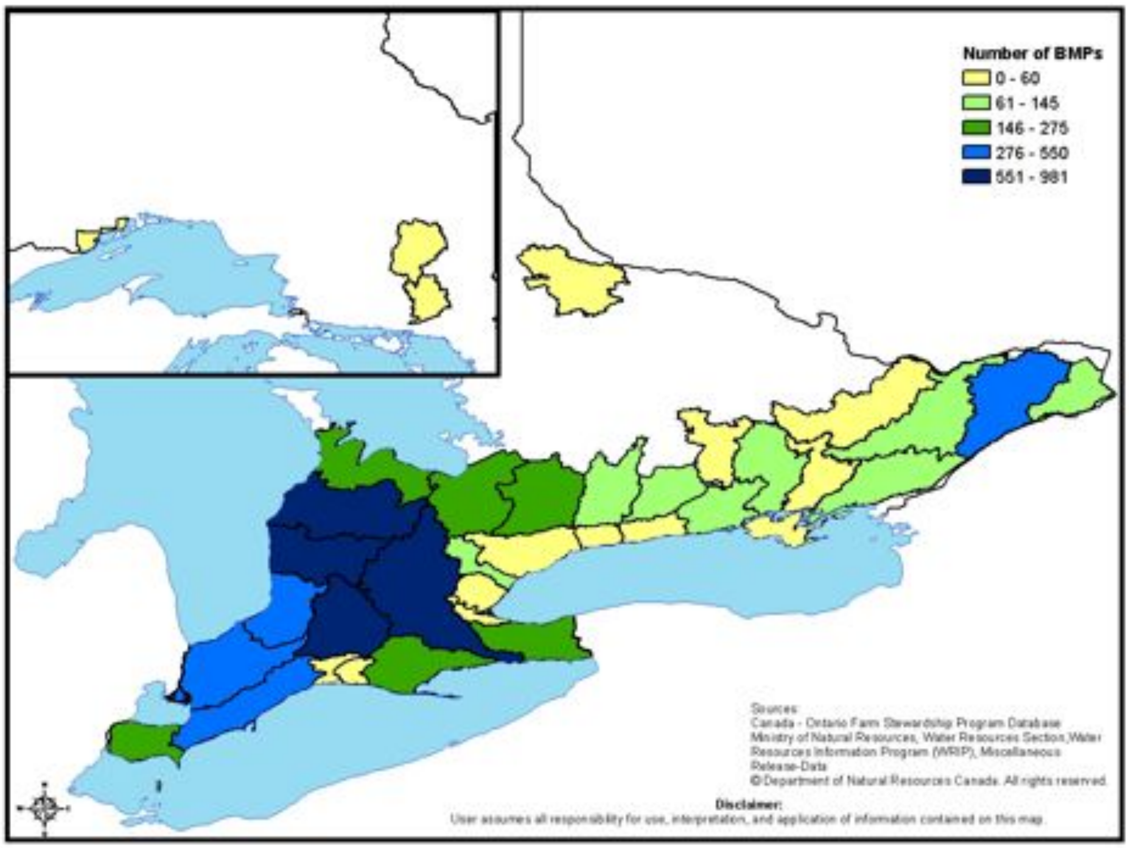

Figure 14: Number of nutrient management related BMPs adopted during COFSP (April 2005-March 2010) by Conservation Authority

Livestock Nutrient Management BMPs Adoption by Watershed

The BMP data from COFSP is collected at a conservation authority level, while the data used from the 2006 Interpolated Census of Agriculture (commercial fertilizer use and livestock numbers that were used for the manure/nutrient calculation) were taken at a sub-sub drainage area level. Due to these differing scales, the two layers had to be mapped using different features to distinguish the varying boundaries. As a result in Figures 15 to 18 blue outlines represent the CA boundaries which overlay the black outlined Sub-Sub Drainage Areas (SSDA) from the Census.

The map in Figure 15 shows both the number of livestock related nutrient management BMPs adopted within a CA and the amount of manure produced per hectare of farmland by SSDA. The four watersheds with the highest number of livestock nutrient management related BMPs (> 500) adopted match the top four municipalities in Ontario with the most manure produced per hectare, and included the Saugeen, Grand River, Maitland Valley and Upper Thames watersheds. Crowe Valley (part of the Trent drainage area), Lakehead (part of the Dog drainage area), Mississippi Valley, Ganaraska, North Bay-Mattawa (part of the Kipawa drainage area) and Halton watersheds had a moderate (4,501-6,874 kg) amount of manure produced (areas shaded in orange), yet a small number of livestock nutrient management BMPs being adopted (indicated by a small black dot). The situations are the same for both phosphorus produced from manure (Figure 16) and nitrogen produced from manure (Figure 17). Roughly 50% of the farmland in the Halton and Credit River watersheds (part of the Credit-Sixteen Mile SSDA) and 41% of the farmland in the Ganaraska watershed is rented; both of these areas are within the Greater Toronto Area. This could explain the lower adoption of livestock nutrient management related BMPs in these near-urban areas. It has been shown in previous studies that producers that rent land do not have incentives or motivation to financially invest in long-term management for soil conservation of land they do not own (Fraser, 2002).

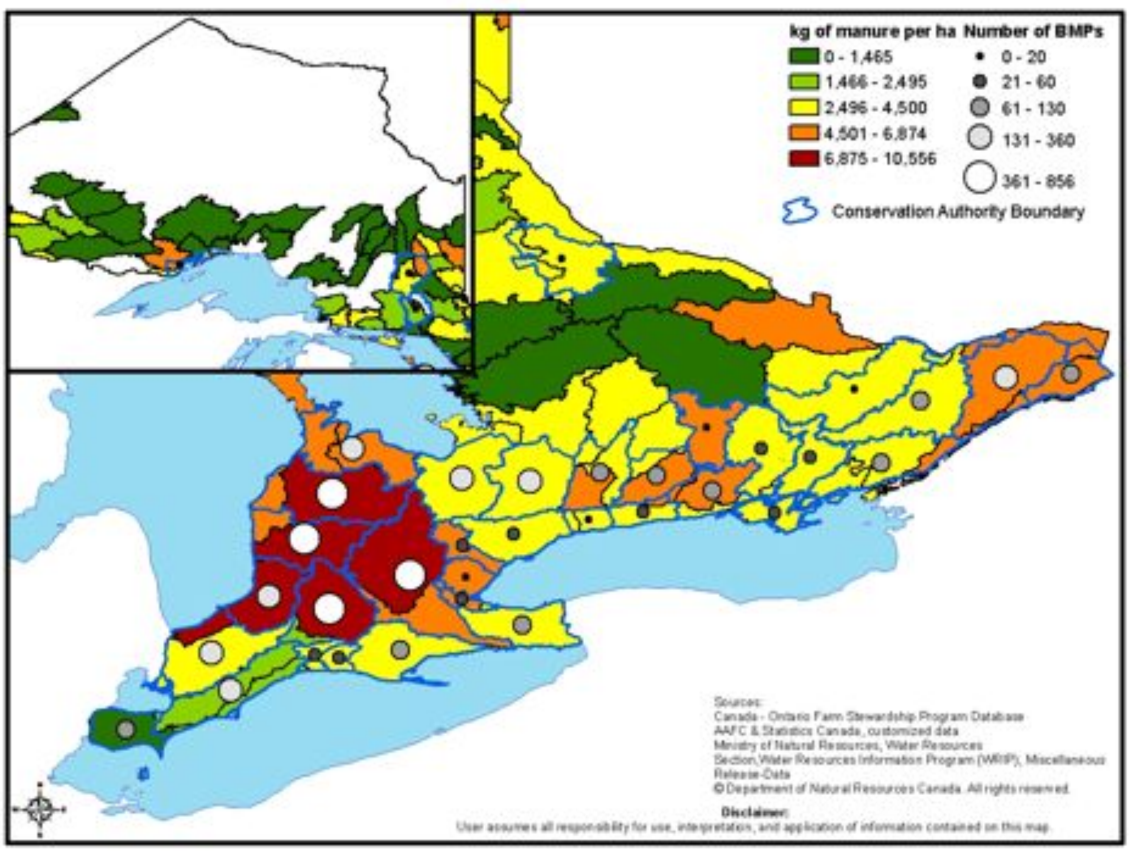

Figure 15: Comparison between manure produced per hectare of farmland in 2006 per SSDA and number of livestock nutrient management BMPs adopted during COFSP (April 2005-March 2010) by CA

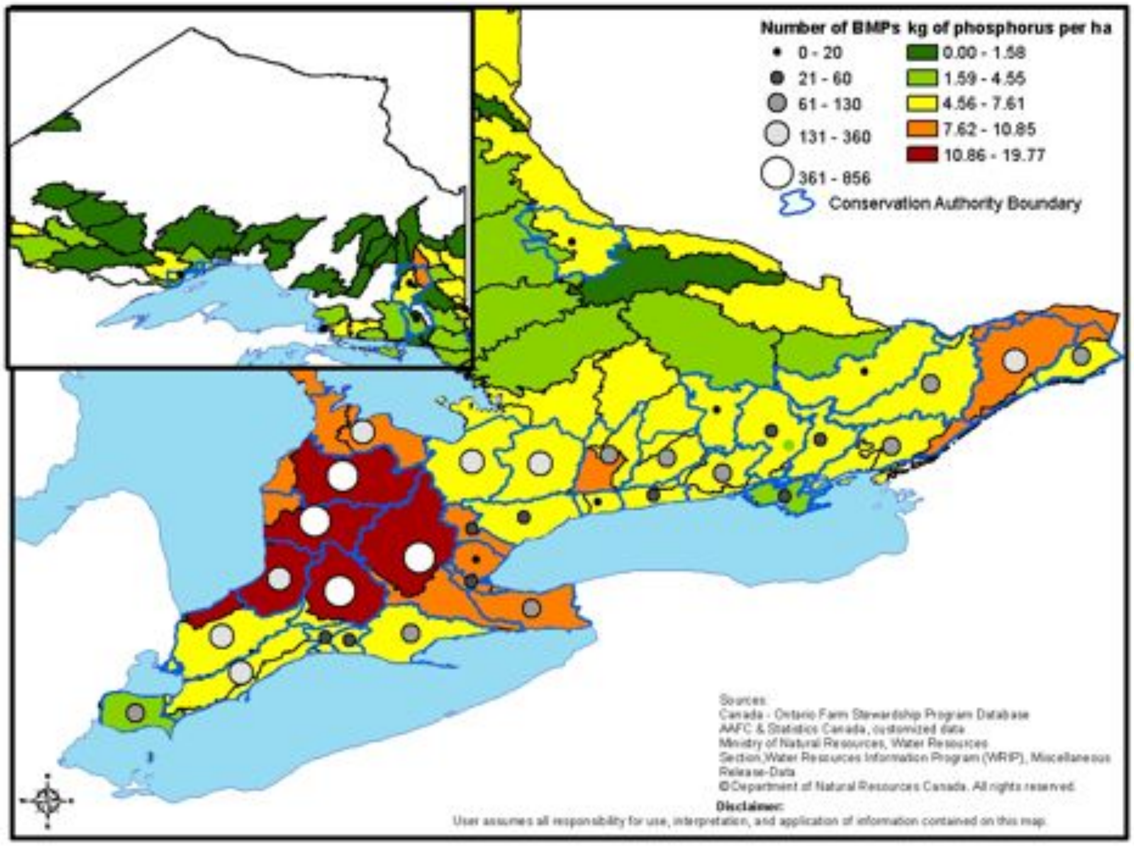

Figure 16: Comparison between phosphorus produced from manure per hectare of farmland in 2006 per SSDA and number of livestock nutrient management BMPs adopted during COFSP (April 2005-March 2010) by CA

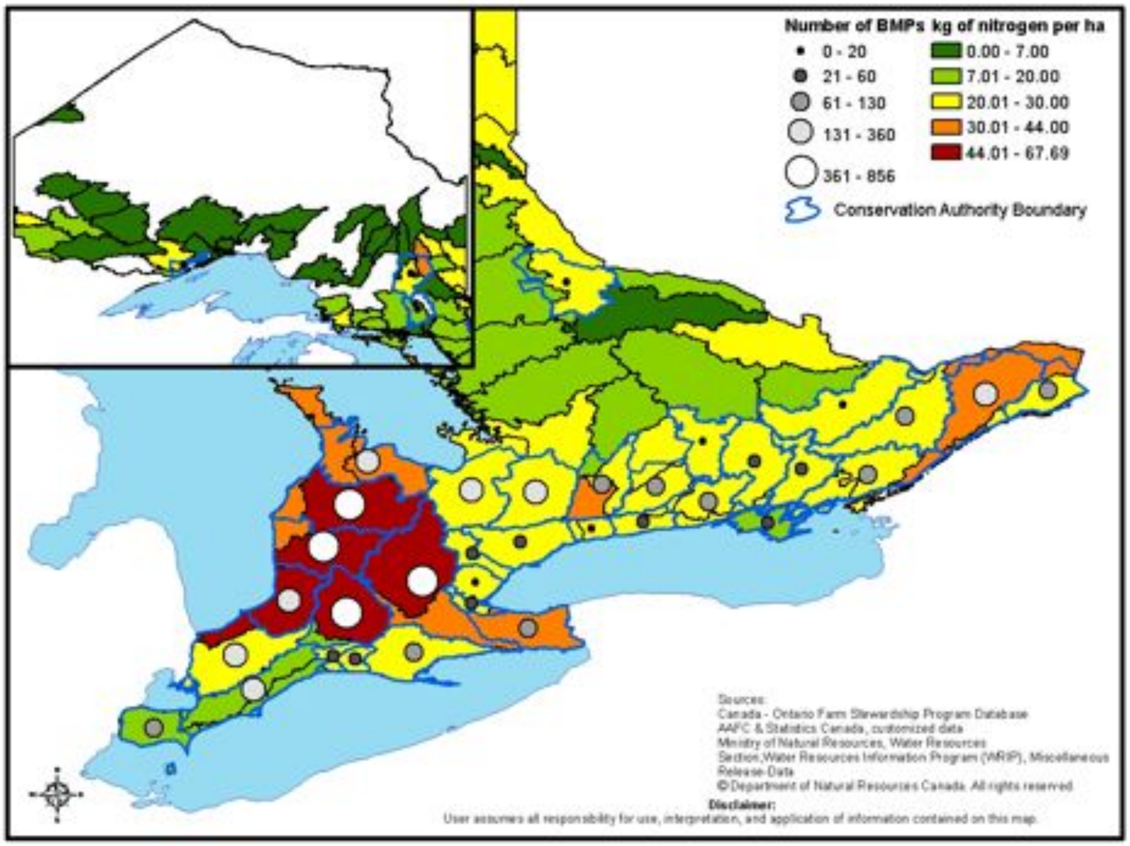

Figure 17: Comparison between amount of nitrogen produced from manure per hectare of farmland in 2006 by SSDA and number of livestock nutrient management BMPs adopted during COFSP (April 2005-March 2010) by CA

Crop Nutrient Management BMPs Adoption by Watershed

In general, a large number of crop nutrient management related BMPs have been adopted in watersheds where producers use large amounts of commercial fertilizer (Figure 18). The highest number of the crop nutrient management related BMPs were adopted in the Lower and Upper Thames, Grand River, St. Clair, Ausable Bayfield and Maitland Valley Conservation Authorities; these are watersheds that have the greatest area of fertilized land in Ontario. Kettle Creek, Catfish, and Long Point watersheds, part of the Big Creek sub-sub drainage area are watersheds with a high area with fertilizer applied but have fewer crop nutrient management related BMPs adopted, perhaps due to the small size of the conservation authorities. Producers in this area may have less of an opportunity to adopt crop nutrient management BMPs.

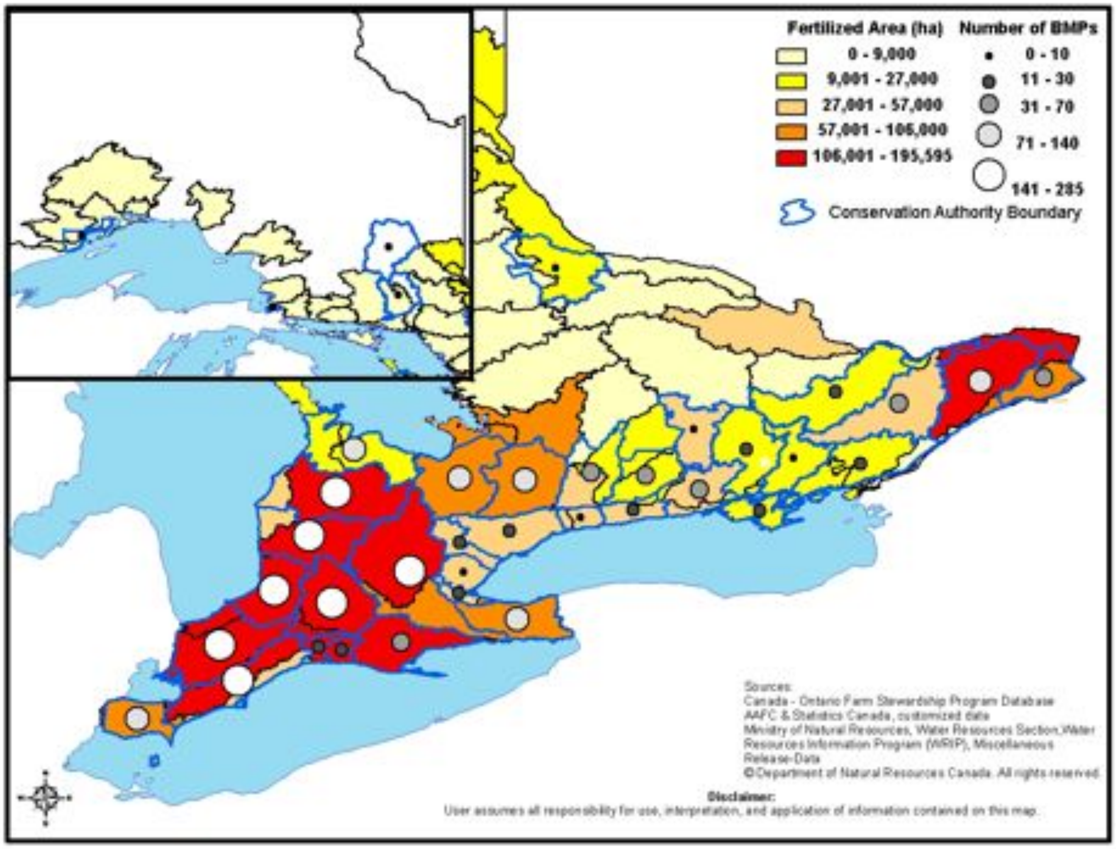

Figure 18: Comparison between area of commercial fertilizer inputs in 2005 by SSDA and number of crop nutrient management BMPs adopted during COFSP (April 2005-March 2010) by CA