Beneficial Management Practice (BMP) Adoption by Canadian Producers

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March 2010

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Master of Science

ABSTRACT

Agricultural activities alter landscapes to produce food and fiber and can pose a risk to the health of the soil, water and air, and impact biodiversity. The environmental impact of agriculture is largely influenced by the management practices implemented on farms. Beneficial management practices (BMPs) can help mitigate risk to the environment and improve the health of the soil, water, air and biodiversity. In order to develop effective agri-environmental policies and programs to promote environmental sustainability, decision-makers at all levels of government require science-based information on the environmental performance of agriculture, including information on practices being implemented on the farm. Information about BMP adoption in Canada has, until now, been largely fragmented and not widely available. In this study I developed a BMP Adoption Index, which is a reporting tool that measures the level BMP adoption in Canada and can be used to inform policy and program development. The BMP Adoption Index suggests that average adoption by both crop and livestock farmers across the country is in the medium range, with producers implementing more BMPs in areas where agriculture is a dominant land use. BMP Adoption across Canada does not appear to be motivated by a particular environmental issue or high environmental risk. Further investigation to identify the drivers of BMP adoption will enable decision makers to help farmers increase BMP adoption where they will be best able to mitigate the environmental risks of agriculture.

RÉSUMÉ

Les activités agricoles de production d'aliments et de fibres altèrent les paysages. Elles peuvent constituer un risque pour la qualité du sol, de l'eau et de l'air, et avoir des répercussions sur la biodiversité. L'impact de l'agriculture sur l'environnement est en grande partie dû aux pratiques de gestion mises en œuvre dans les exploitations agricoles. Les pratiques de gestion bénéfiques (PGB) peuvent aider à réduire le risque pour l'environnement, améliorer la qualité du sol, de l'eau et de l'air et préserver la biodiversité. Afin de concevoir des politiques et des programmes agroenvironnementaux efficaces pour promouvoir la durabilité environnementale, les décideurs de tous les ordres de gouvernement ont besoin de renseignements fondés sur la science concernant la performance environnementale de l'agriculture, y compris des renseignements sur les pratiques mises en œuvre à la ferme. Les renseignements concernant l'adoption des PGB au Canada ont été transmis de manière fragmentée jusqu'à aujourd'hui, et n'ont jamais été mis à la disposition du grand public. Dans le cadre de cette étude, j'ai conçu un indice d'adoption des PGB ; un outil de présentation de données qui mesure le niveau d'adoption des PGB au Canada et qui peut être utilisé pour éclairer l'élaboration des politiques et des programmes. L'indice d'adoption des PGB donne à penser qu'en général, l'adoption par les cultivateurs et les éleveurs de bétail du Canada se situe dans la fourchette moyenne, les producteurs mettant en œuvre plus de PGB dans les zones où l'agriculture constitue l'utilisation principale de la terre. L'adoption des PGB au pays ne semble pas être motivée par un problème environnemental particulier ou un risque environnemental élevé. La poursuite des investigations afin d'identifier les facteurs déterminant pour l'adoption de PGB, permettra aux preneurs de décision de mieux aider les producteurs agricoles à augmenter l'adoption des PGB leur permettant de réduire les impacts environnementaux de l'agriculture.

ACKNOWLEDGEMENTS

First, I would like to thank my supervisor, Dr. Elena Bennett, for her continued support, ideas and advice throughout this process. Her encouragement and enthusiasm for my work throughout my M.Sc. has been invaluable to me. My co-supervisor, Alexandre Lefebvre at Agriculture and Agri-Food Canada has also been instrumental to my success throughout this program. He had the original idea for this work and has provided ideas, support and encouragement at every stage of the process. I could not have asked for better supervisors. I would also like to thank my committee members Dr. Guy Mehuys and Dr. Sylvie deBlois for their feedback and comments throughout this process.

For the past three years I have been lucky enough to be part of the 'Uberlab', a joint lab group with Dr. Bennett and Dr. Garry Peterson, and more recently Dr. Bennett's 'Beeslab'. While geography only allowed me to be in attendance at the lab meetings occasionally, the time I did spend with the other students was extremely valuable to me. The ideas shared and sense of curiosity within the two groups was infectious and continued to motivate me even when I was working remotely.

Thanks to Lea Herzig who created all my maps and patiently responded to all the changes I requested. I would have been lost without your mapping help. Also, thanks to Janet Murphy for re-formatting all the maps and tables to be print-ready for submission.

I would like to thank Jamie Hewitt, Warren Eilers, Dennis Haak, Tim MacDonald and Bahram Daneshfar at Agriculture and Agri-Food Canada. Jamie, Warren, Dennis and Tim allowed me to bounce ideas off them at any time and were always eager to provide feedback and sometimes engage in a lively debate about my work. Bahram provided technical advice for setting up the model calculation, and was always willing to offer suggestions and feedback. Graham MacDonald was also always helpful with his advice and feedback.

I would like to acknowledge Agriculture and Agri-Food Canada who provided funding and support for this project throughout my program. Without this support, this project and M.Sc. would not have been possible.

Finally, I would like to thank my mother Nicole for her support and my partner Tyler for his continued belief in me, his patience, and constant encouragement to achieve my goals. I also want to thank my friends and family who were always curious about what I was doing and always quick to provide encouragement and pep talks. Your support means so much to me.

THESIS STYLE AND CONTRIBUTIONS OF CO-AUTHORS

This is a manuscript-based thesis. As a result, there is some necessary repetition in the text. After submission of this thesis, Chapter 2 will be prepared as a manuscript for submission to an ecological journal yet to be determined. Chapter 1 is not targeted for submission to a journal, but will likely contribute to the manuscript arising from Chapter 2.

I wish to acknowledge the important contributions of the co-authors in Chapter 2, Dr. Elena Bennett and Alexandre Lefebvre. Dr. Bennett and Mr. Lefebvre have contributed conceptual support and advice to this project at every stage of its development as advisors, and will continue to provide guidance in the preparation of the resulting manuscript.

The candidate declares that she was responsible for the compilation of the data in Chapter 2, planning specific details with the research approach, all data analysis (the maps were created by Lea Herzig) and all writing that was necessary to complete this project. She will continue to be responsible for the writing necessary to prepare the resulting manuscript.

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INTRODUCTION

Agricultural activities such as clearing land, moving soil, filling natural potholes and wetlands, digging ditches, redirecting water for irrigation, housing large populations of animals, storing manure, and adding inputs such as manure, fertilizer and pesticides to the soil can pose risks to the environment such as soil erosion and soil structure breakdown which can reduce soil fertility (Skidmore et al. 1986), reduced capacity to provide habitat for wildlife which can lead to declines in biodiversity (Javorek and Grant 2010), compromised water quality by eliminating natural purification systems and increasing contamination (Easton et al. 2008, Prokopy et al. 2008), and reduced air quality through nutrient volatilization and emission of greenhouse gases (Dale and Polasky 2007, Eilers et al. 2010). The practices that farmers implement on their land largely influence the environmental performance of their operation (van der Werf and Petit 2002), and ultimately, the agriculture sector. Beneficial management practices (BMPs) address existing environmental issues, reduce overall environmental risk and enhance benefits provided by agriculture (Hilliard and Reedyk 2003, Smiley et al. 2009). Examples of BMPs include erecting physical structures such as manure tanks or fencing along waterways, establishing buffer vegetation along stream banks, implementing conservation or reduced tillage, and developing detailed nutrient management plans (AAFC 2003). The expected result of implementing BMPs is that the negative impacts of agriculture on the environment will decrease and environmental condition will improve.

Managing risks to the environment by agriculture requires effective agri-environmental policy that is informed by credible, science-based information (Pretty 2008, OECD 2006). However, it can be a challenge to integrate technical ecological information into policy since it is often not in a synthesized form that is useable by policy makers (Kinzig 2001). Environmental indicators can be used to synthesize this information and communicate it in a way that is useful to policy makers by highlighting key relationships and large-scale patterns in the environment that can be used to inform decision makers and the public (Niemi and McDonald 2004, Niemeijer 2002, Bohringer and Jochem 2007). Indicators can also help identify cause-effect relationships for policy makers that show the relationship between the practices farmers are implementing and the resulting impact on the environment (Piorr 2003, OECD 2001), and can therefore be used to evaluate whether agri-environmental policies are meeting their objectives (Alberti and Parker 2001, Hajkowicz 2006, Schroder et al. 2004). Finally, because of their simplicity, indicators can help policy-makers more easily communicate environmental information to the public (Bohringer and Jochem 2007).

Current research on BMPs and other agri-environmental practices is largely focused on determining the efficacy of practices in mitigating risk and providing benefits to the environment, and identifying drivers and barriers to adoption of these practices (Hickey and Doran 2004, Shelton 2004, Knowler and Bradshaw 2007). Both Canada and the United States have collected information on BMP adoption through surveys and small scale field studies (Filson et al. 2009, Rodrigues et al. 2009), and in Canada some provinces and conservation groups collect information on adoption, however this information is not widely available and not organized in a way that is useful to inform policy development at a national or regional scale. Understanding which BMPs are being adopted and where they are being implemented on the landscape can help decision-makes target areas where adoption is low and learn from the successes in regions where adoption is high, or target areas where increased adoption is required to mitigate environmental risk.

RESEARCH QUESTIONS AND OBJECTIVES

In response to this gap in information, I have developed a Beneficial Management Practice Adoption Index indicator using data from the 2006 Farm Environmental Management Survey (Statistics Canada 2007), which asked producers across Canada about the practices being implemented on their farms during the 2006 growing season. The results of this work summarize the level of BMP adoption across Canada for all farms, by major farm type (crop and livestock), and by ecozone-ecoregion. The BMP Adoption Index is then integrated with information about environmental condition to answer the following questions:

1. What is the pattern of BMP adoption across agricultural regions in Canada? How does BMP adoption compare across provinces? Across farm types?

2. Are certain environmental issues being addressed by producers more than others?

3. Do farmers of some commodities (i.e. crop, livestock) implement more BMPs than others?

4. Is the level of effort by producers consistent with the level of risk as assessed by agri-environmental indicators?

THESIS OUTLINE

A review of the literature, **Chapter 1**, examines the evolution of agri-environmental policy over the last thirty years and highlights the challenges in integrating science into the policy development process. The current research on the development of environmental indicators is examined, as well as research on agricultural beneficial management practices. **Chapter 2** presents the justification and methodology for developing the BMP Adoption Index, as well as presenting an analysis of the results and demonstrating how the tool can be used. The main conclusions and future directions for this work are presented following Chapter 2.

CHAPTER 1: REPORTING TOOLS AND PERFORMANCE MEASURES FOR AGRI-ENVIRONMENTAL POLICY DEVELOPMENT – AN OVERVIEW

Agricultural sustainability and agricultural policies

Historically, agricultural policies have focused on increasing production of food, relying on inputs such as fertilizers and pesticides or on expansion of land area dedicated to farming (OECD 2001, Dale and Polasky 2007, Sydorovych et al. 2009). The tradeoff of increased production as a result of these policies has been environmental impairment and degradation, which in the past was considered an unavoidable consequence of food production and a cost that was expected to be borne by society (Piorr 2003, van der Werf and Petit 2002, Metzger 2006).

Since the 1970's, the focus of agricultural policies has shifted to include the concept of sustainability and towards improving the health of soil, water, air and biodiversity in agricultural landscapes (Lewis et al. 1998, Kassam 2009). In Europe, this has resulted in policies to reduce externalities due to production intensity and promote practices that increase benefits to the environment (OECD 2001, Robinson 2006). In Canada the focus has been on implementing practices to reduce environmental impact while continuing to encourage growth in the agricultural sector (Atari et al. 2009). The shift in policy towards reducing environmental impact has been driven by the increased awareness of the environmental pressures attributed to agriculture and has been supported by an increasingly large body of research on the effect of agriculture on the environment (Pretty 2008, van der Werf and Petit 2002).

Linking science to policy and environmental indicators

Effective agri-environmental policy must be informed by strong, credible science, be well targeted and include measurable objectives that can be evaluated for success or failure (Piorr 2003, OECD 2006). The challenge, however, is that the interactions between agriculture and the environment are complex and not always well understood (Sattler et al. 2010, Mondelaers et al. 2009) and it can therefore be difficult to determine the best practices for any one particular situation. Complicating this issue, most research is focused on specific agri-environmental interactions in localized situations and is often unorganized and unsynthesized for broad scale analysis, making it nearly unusable by policy makers who are interested in more than one issue or more than one small location (Niemi and MacDonald 2004, Alberti and Parker 1991, Metzger 2006).

Environmental indicators are tools that can be used to integrate complex ecological information into a form that is more easily understandable and applicable at a broad scale, and therefore more useful to policy makers. A good indicator is scientifically sound, easily measurable, sensitive to change, responds to change in a predictable manner, predicts changes that can be averted by management actions, and be integrative with other measures of the environment. When constructing an indicator, it is important to clearly identify its objective and its target audience to ensure it provides the required information while remaining understandable to its audience (Girardin et al. 1999). Being economically feasible to develop and maintain is also a requirement of a good indicator (Eilers et al. 2010, Bockstaller et al. 2008).

Indicators can assess conditions of the environment, monitor trends in conditions over time, provide an early warning sign of changes in the environment and supply explanations for the cause of an environmental problem (Dale and Polasky 2007, Lefebvre et al. 2005). They measure a particular aspect of the environment and can "provide a useful tool to highlight environmental conditions and trends for policy purposes as they have the ability to isolate key aspects from an otherwise overwhelming amount of information and help highlight the larger patterns so policy makers can determine appropriate action" (Niemeijer 2002, p. 91). Indicators can also help identify cause-effect relationships between the practices farmers are implementing and the resulting impact on the environment for policy makers (Piorr 2003, OECD 2001), and can therefore be used to evaluate whether agri-environmental policies are meeting their objectives (Alberti and Parker 2001, Hajkowicz 2006, Schroder 2004). Finally, indicators, because of their simplicity can help policy-makers more easily communicate environmental information to the public (Bohringer and Jochem 2007).

Indicators can measure the state of a problem or its solution, such as the level of nitrate in streams or the number of management practices being implemented on a farm. They can identify pressures on the environment such as level of greenhouse gas emissions from agricultural activity, or the response to problems such as the number of regulations established to mitigate the environmental impact of agriculture (Niemeijer 2002, OECD 2001). They are based on quantitative data as much as possible but when this is not available, semi-quantitative or qualitative data can be used. Indicator data can be directly measured (i.e taking stream samples at regular intervals to measure nutrient concentrations over time), indirectly measured (such as by survey data), estimated from modeled data (i.e integrating biophysical characteristics of a region with land use information often collected by survey to estimate outcomes of activities) or a combination of all three, which is usually determined by financial resources, available data, the complexity of the system, and the purpose of the indicator (Girardin et al. 1999). Some indicators require calculations that include mathematical transformations such as applying weights and aggregating data if more than one variable is being considered. Particularly in these cases, transparency of the construction methods is essential. Conducting sensitivity analysis and validation of the indicator is also important to verify that it presents an accurate representation of actual ecological relationships (Girardin et al. 1999).

Despite the care taken to develop environmental indicators, they are often criticized for simplifying large amounts of technical information, resulting in the loss of detail and therefore possibly leading to an inaccurate interpretation of the data (van der Werf and Petit 2002, Andreoli and Tellarini 2000, Alberti and Parker 1991). Others have suggested that weighting and aggregating data to a single measure introduces an unacceptable element of subjectivity (Bockstaller et al. 2008). However, proponents of indicators argue that some loss of detail is acceptable and contend that the benefits of having simple measures of environmental quality to inform decisions outweigh the disadvantages of simplification (Alberti and Parker 1991, OECD 2006, USEPA 1990).

Integrating indicators into the decision making process can be challenging, however. A key reason for this is the inherent uncertainty associated with indicators due to incomplete ecological knowledge (Francis et al. 2005). Moore et al. (2009) suggest that policy makers are less comfortable using indicators when there are high levels of uncertainty or diverging opinions from scientists, and are more likely to use them when scientists are in agreement. It is important for scientists to be clear about the limitations of indicators and also demonstrate how their tools can be used by decision-makers in order to ensure they are integrated into the policy and program-making process. Kinzig (2001) suggests that tools that communicate ecological information such as environmental indicators are essential, otherwise "trying to understand all the complexities of an ecological system before making a decision would result in management paralysis" (p.714).

Beneficial management practices

Agri-environmental indicators provide an assessment of the state of the environment at a broad scale that can inform policies, however the environmental performance of agricultural landscapes is ultimately dependent on the management practices a farmer implements (OECD 2001, Stobbelaar et al. 2009). For this reason, information about what practices farmers are implementing on their farms is critical to understanding and predicting the impact of agriculture on the environment (Andreoli and Tellarini 2000). Beneficial Management Practices (BMPs) are methods and practices that reduce the environmental impacts of agriculture on terrestrial and aquatic ecosystems. They are intended to reduce erosion, improve water quality and reduce emissions into the air (Smiley et al. 2009). Feather and Amacher (1994) expanded on this definition to include that BMPs are at least as profitable economically as other practices.

Many studies have attempted to determine the effectiveness of BMPs in reducing environmental risk and improving condition (Shelton 2004, Hiddink et al. 2007, Chen et al. 2000, Tong and Naramngam 2007, Hutchison et al. 2004, Griffith et al. 1988, Malhi and Lemke 2007, Wyland et al. 1996). These studies have found that the efficacy of BMPs can be measured for specific study areas, however the results are not always consistent with results for the same BMPs at other sites (Sharpley et al. 2009, Hickey and Doran 2004, Easton et al. 2008, Gitau et al. 2005) which makes synthesis of BMP efficacy particularly difficult. Gitau et al. (2005) developed a model that could combine the results from many different studies to determine the overall efficacy of a few BMPs that reduced phosphorus (P) runoff into streams. They found that the ability of various BMPs to reduce P runoff was largely based on soil type and slope, suggesting that in fact BMP efficacy is determined in large part by local conditions. Despite our inability to synthesize across regions, all of these studies indicate that BMPs used properly and in the right conditions can reduce risk and improve environmental performance.

Concurrent to the work on BMP efficacy, research is being done to determine the drivers of BMP adoption by producers (Knowler and Bradshaw 2007, Feather and Amacher 1994). This information is important in order to better design policies and programs to increase BMP adoption. BMP adoption by producers is largely driven by whether producers perceive there to be economic benefits (OECD 2001), by regulation, or conversely, the desire to remain unregulated, the amount of information about the practice available to the farmer, and the desire for producers to be regarded as stewards to the land by their peers (Knowler and Bradshaw 2007, Prokopy et al. 2008, Feather and Amacher 1994, Smiley et al. 2009, Rodriguez et al. 2009). Interestingly, researchers are still struggling to determine the level of BMP adoption in many places.

Research needed

While most of the BMP work up to now has focused on efficacy and drivers, there has not been much research on the levels of adoption in Canada or the United States (Rodrigues et al. 2009, Filson et al. 2009). Both Canada and the US have collected survey information on BMP adoption (Statistics Canada 2001, 2007, Caswell et al. 2001) to better understand what practices are being implemented by producers and where they are being implemented, however this information has not been compiled into a form that can communicate overall BMP adoption at a regional or national scale. This information would be useful for policy makers to better target areas where risk to the environment is high, or areas where BMP adoption is low and to assess the overall level of effort being expended by producers. It would also be useful information to assess the success of programs that aim to encourage producers to adopt BMPs. Rodriguez et al. (2009) suggest that this type of information is very important for making informed decisions and developing strategies to promote sustainable agriculture. An indicator is required to synthesize

BMP adoption information into a form that is useable by decision-makers.

Environmental management requires a systems approach (Pretty 2008). Many factors contribute to agri-environmental sustainability and it is nearly impossible to manage a farm without considering the farm's place in the larger ecosystem. At the same time, the environmental performance of agriculture is largely dependent on the management practices being implemented at the farm level, therefore any measure of sustainability must consider both the landscape and farm level scale (Ikerd 1993, Sydorovych 2009). Future work must consider the practices that are being implemented on the farm, as well as combinations of practices being implemented to fully understand how the ecosystem is being impacted, and this information needs to be incorporated into policy decisions alongside the data on environmental quality.

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PREFACE TO CHAPTER 2

In Chapter 1, I discussed the role of using credible, science-based indicators to inform agri-environmental policy development, and highlighted the important influence that beneficial management practices (BMPs) have on the environmental performance of agriculture. While overall BMP adoption information is an important element of informing agri-environmental policy, this information is unknown at a national scale in Canada. In Chapter 2 I develop an indicator to estimate BMP adoption across Canada.

CHAPTER 2: BENEFICIAL MANAGEMENT PRACTICES (BMPs) IN CANADA: THE DEVELOPMENT OF A BMP ADOPTION INDEX

ABSTRACT

Agricultural activities alter landscapes to produce food and fiber and by doing so can pose a risk to the health of the soil, water and air, and impact biodiversity. Agriculture's impact on the environment is largely influenced by the management practices implemented on farms. Beneficial management practices (BMPs) can help mitigate risk to the environment and improve the health of the soil, water, air and biodiversity. In order to develop effective agri-environmental policies and programs to promote environmental sustainability and manage risk, decision-makers at all levels of government require science-based information on the environmental performance of agriculture, including information on practices being implemented on the farm. Information about BMP adoption in Canada has, until now, been largely fragmented and not widely available for decision makers. In this study, we developed a BMP Adoption Index; a reporting tool to measure the level BMP adoption in Canada that can be used to inform policy and program development. The BMP Adoption Index suggests that average adoption by both crop and livestock farmers across the country is in the medium range, with producers implementing more BMPs in areas where agriculture is a dominant land use. BMP Adoption across Canada does not appear to be motivated by a particular environmental issue or associated with high environmental risk. Further investigation to identify the drivers of BMP adoption will enable decision makers to help farmers increase BMP adoption where they will be best able to mitigate the environmental risks of agriculture.

INTRODUCTION

Agricultural operations that manipulate the landscape in order to obtain food and fiber can pose a critical risk to the on- and off-farm environment (Eilers et al. 2010, Millenium Ecosystem Assessment 2003). This manipulation can include clearing land, moving soil, filling natural potholes and wetlands, digging ditches, redirecting water for irrigation, housing large populations of animals, storing manure, and adding inputs such as manure, fertilizer and pesticides to the soil. Such actions increase food production, however many also pose a risk to the environment (Dale and Polasky 2007). These risks include soil erosion and soil structure breakdown which can reduce soil fertility (Skidmore et al. 1986), reduced capacity to provide habitat for wildlife which can lead to declines in biodiversity (Javorek and Grant 2010), compromised water quality by eliminating natural purification systems and increasing contamination (Easton et al. 2008, Prokopy et al. 2008) and reduced air quality through nutrient volatilization and emission of greenhouse gases (Dale and Polasky 2007, Eilers et al. 2010).

Science-based, credible and timely information on the environmental performance of the agriculture sector is essential for decision-makers to establish policies to mitigate environmental impacts and protect air, water, soil and biodiversity (OECD 2006). However, integrating scientific information into policy decisions can be challenging given that the information available is often highly technical, informative only about a particular location or set of criteria, unsynthesized, and therefore overwhelming and under-useful to decision-makers (Francis et al. 2005). Environmental indicators can be used to synthesize this technical ecological information and communicate it in a way that is useful to policy makers by highlighting key relationships and large-scale patterns in the environment that can be used to inform decision makers and the public (Niemi and McDonald 2004, Niemeijer 2002, Bohringer and Jochem 2007). The integrated information that indicators provide can also help assess the effectiveness of policies by measuring trends in environmental performance when indicators are measured repeatedly over time (OECD 2006).

In response to the need for science-based environmental information, Agriculture and Agri-Food Canada (AAFC), under the National Agri-Environmental Health Analysis and Reporting Program (NAHARP) has developed a set of science-based agri-environmental indicators (AEI) to assess the environmental performance of the agriculture sector and track progress toward the department's stated environmental goals of reducing agricultural risk to the environment and providing benefits to the health and supply of water, soils, air and atmosphere and ensure compatibility between agriculture and biodiversity (Lefebvre et al. 2005, AAFC 2003). The

AEIs provide a practical means of assessing environmental sustainability by combining current scientific knowledge and understanding with most recent information on resources and land use. They are mathematical models that integrate biophysical information such as climate, topography and soil type with agricultural land use data such as the type of crop being grown or the number of heads of livestock to estimate the risk of agriculture to the environment (Lefebvre et al. 2005). AAFC regularly reports on thirteen agri-environmental indicators in 4 categories: risks to soil, air, water, and biodiversity (Table 1).

The environmental impact of agriculture is largely influenced by the choice of production practice implemented by the farmer (van der Werf and Petit 2002). Practices can have positive, negative or little impact on both production and the environment (OECD 2001). Practices that reduce the environmental impact of agriculture, referred to as Beneficial Management Practices (BMPs), are often developed by scientists and agronomists in partnership with producers, government, academia, producer groups and conservation associations to address existing issues, reduce overall environmental risk and enhance benefits provided by agriculture. They are typically designed to be economically feasible for the farmer (Hilliard and Reedyk 2003, Smiley et al. 2009, Feather and Amacher 1994). Examples of BMPs include erecting physical structures such as manure tanks or fencing along waterways, establishing buffer vegetation along stream banks, implementing conservation or reduced tillage, and developing detailed nutrient management plans (AAFC 2003). The expected result of implementing BMPs is that the negative impacts of agriculture on the environment will decrease and environmental condition will improve.

Research on BMPs is mostly focused on determining the efficacy of particular practices in mitigating particular negative environmental impacts with the objective of identifying practices that best contribute to environmental sustainability for a single issue (Hickey and Doran 2004, Shelton 2004, Chen et al. 2000, Tong and Naramngam 2007, Hutchison et al. 2004). Other research examines the drivers of and barriers to BMP adoption by producers in order to better understand how to target policy and programming and increase the uptake of these practices (Knowler and Bradshaw 2007, Prokopy et al. 2008, Feather and Amacher 1994, Smiley et al.

2009). These studies suggest that overall, BMPs have a positive impact on the environment and reduce environmental risk, although the level of BMP efficacy can be variable across regions and scales. Producers will only implement BMPs if it makes economic sense, but are also influenced by other drivers including regulation, the desire to avoid being regulated, and their peer group. Other socio-economic factors such as age and level of education may also influence adoption.

Information on BMP adoption is important for evaluating whether management efforts by producers are appropriate to meet environmental objectives. Understanding the level and location of BMP adoption can help policy makers better identify areas where more attention is required and develop policies and programs to mitigate the environmental impact of agriculture. Some efforts have been made to measure levels of BMP adoption (Lewis and Bardon 1998, Filson et al. 2009) as a way to determine environmental sustainability of agriculture with the goal of quantifying the environmental impact of BMP adoption. In general, these studies have been successful in demonstrating that environmental performance improves as BMP adoption increases, however these studies have generally been undertaken at small scales and address only a few, specific environmental issues and BMPs for which adoption data is available.

In Canada, BMP adoption information is collected by many organizations and levels of government but has not been synthesized to provide information on overall BMP adoption across the country. For example, Quebec conducts their own agri-environmental survey to collect information on farm practices, and many other provinces collect information on funding provided to producers to implement specific BMPs (AAFC 2010). The information is largely fragmented however (i.e., information is gathered only on a few BMPs or a few locations), not comparable across provinces, and not widely available. A comprehensive summary of BMP adoption in Canada would help policy-makers better target areas where adoption is low in order to improve environmental performance, or identify areas where adoption is high and learn from this success.

To meet this need, I have developed a tool that summarises the level of BMP adoption across Canada. My newly-developed BMP Adoption Index identifies the management practices being implemented on farms and integrates this information with farm type (i.e., livestock or crop) and relative BMP efficacy to provide information about whether BMPs are being used in areas where they are most needed. I integrate this with information about environmental condition to answer the following questions:

- What is the pattern of BMP adoption across agricultural regions in Canada? How does BMP adoption compare across provinces? Across farm types?
- Are certain environmental issues being addressed by producers more than others?
- Do farmers of some commodities (i.e. crop, livestock) implement more BMPs than others?
- Is the level of effort by producers consistent with the level of risk as assessed by agri-environmental indicators?

I hypothesize that BMP adoption will have a direct relationship with the environmental issues present in each region. That is, I expect high adoption where risk is high, and low adoption where risk is low. I expect that BMP adoption will also be higher in regions where there are high levels of environmental regulations.

METHODS

I developed the BMP Adoption Index using the Farm Environmental Management Survey (FEMS) data set (Statistics Canada 2007). The Index calculation combines the management practices being implemented on farms in 2006 with a ranking that reflects the efficacy of the management practice in improving the environmental performance of a farm. The Index is calculated by ecoregion and by major commodity type to determine the level of BMP adoption by producers.

The Survey

The Farm Environmental Management Survey (FEMS) was an initiative undertaken by Statistics Canada in partnership with AAFC in February 2007 with the objective of collecting information about the management practices being implemented on Canadian farms during the 2006 growing season. FEMS consisted of two questionnaires, one specific to crop producers and one for livestock producers. The crop questionnaire asked about manure and fertilizer spreading, pesticide application practices, tillage practices and crop residue management (Appendix 1a). The livestock questionnaire asked about livestock housing, manure storage and treatment and grazing management practices (Appendix 1b). Both questionnaires included a section on land and water management, hazardous waste management and environmental farm planning.

Questionnaires were sent to approximately twenty-thousand crop and livestock producers in each of the ten provinces who reported gross receipts of over $10,000 in the 2006 Census of Agriculture. Crop and livestock farms were included in the data set while institutional farms, greenhouses and farms in the Yukon, Nunavut and Northwest Territories were excluded. Producers received either the crop or livestock questionnaire based on how they were identified in Statistics Canada's farm registry, updated from the 2006 Census of Agriculture. Those that were identified as having both crop and livestock operations were sent only one of the questionnaires based on which farm type contributed the majority of their gross farm receipts.

The FEMS was a representative stratified sample, stratified spatially at the national, provincial and modified ecozone-ecoregion level, and also by major commodity in each province. The ecozone is the largest and ecoregion the second largest level in the nested Ecological Classification of Canada classification system (Marshall and Schutt 1999) and is based on mostly biophysical features such as geologic, landform, soil, vegetation, climate, wildlife, water and human factors (Wiken 1986). This classification system is commonly used when undertaking analysis on environmental quality as it considers functioning ecosystems rather than political boundaries. Ecozone-ecoregions that are composed of at least 5% agricultural land were included in the sample. For my study, I split ecozones-ecoregions whenever one crossed a provincial boundary in order to report results provincially as well as by ecozone-ecoregion, resulting in 27 total ecozone-ecoregions (Figure 1).

FEMS was a voluntary survey and the data was collected by telephone interview a week after producers received the questionnaires by mail. The data was collected by Statistics Canada using Computer Assisted Telephone Interview (CATI) software. This software streamlines the data collection process and allows fast and accurate data validation. The response rate for FEMS was approximately 80%, which is considered excellent for a voluntary survey.

Data Set

I used the individual response records from FEMS to calculate the BMP Adoption Index. The FEMS data set is protected under the Statistics Act, which requires that the data only be presented in aggregated form in order to protect the identity of the respondent (Statistics Canada 2009). The FEMS data set was made available to me through a data sharing agreement between Statistics Canada and AAFC. Each record in the data set includes a record ID number and indicates the province and ecozone-ecoregion where the farm is located. It includes the primary farm type (crop farms or livestock farms), the number of responding farms in the sample, a weighting value that indicates how many farms each record represents, and the responses to each of the questions. In total, 94 questions were relevant to this study in the crop questionnaire and 97 were relevant from the livestock questionnaire. I excluded questions that were not directly related to BMP adoption (such as questions about program participation and funding received), or were too complicated for the scope of this study (such as rate of fertilizer application). Each question in the survey asked about the management of a particular aspect of the farm, and provided options for response. For example, Question 6 in the crop questionnaire asked, “what area was prepared prior to planting using each of the following practices?” and gave options of conventional tillage, conservation tillage and no-till/zero-till. All questions followed this same format, and provided between 2-10 different options. Some questions allowed respondents to “check all that apply”, while others allowed only one response. This resulted in 184 possible practice options in the crop questionnaire and 214 possible practice options in the livestock questionnaire. Ninety-six of these practices were common to both questionnaires. The data set contains a total of 6913 records (each representing one farmer’s response) for the crop questionnaire and 6928 records for the livestock questionnaire. When the representative weighting is applied, this represents 152 353 actual farms in Canada. This data set reflects the 80% response rate of the survey, and only includes the records of the respondents who agreed to share their responses with AAFC.

I modified the initial data set in order to calculate the BMP Adoption Index. The questions I excluded that weren't relevant to the study were removed from the data set. I also edited the data set to integrate any 'other, please specify' responses into one of the existing options if applicable. Lastly, I changed some responses from a text response to a numeric response in order for it to be calculated in the BMP Adoption Index. A detailed list of modifications made to the data set is available in Appendix 2.

BMP Adoption Index Development

Ranking Values

Some management practices are more effective than others in reducing risk or providing benefits to the environment (van der Werf and Petit 2002, Lewis et al. 1998). To reflect these differences and facilitate calculating a BMP Adoption score that presents the level of adoption of beneficial practices and incorporates their relative benefit to the environment, I developed a ranking scheme (Table 2) and applied it to each of the 302 practices (88 crop, 118 livestock and 96 common practices) included in the data set. The rankings range from one to five, where five is the most beneficial practice, three is a neutral practice and one is considered the worst practice.

I assigned two types of rankings to each practice. An overall rank was assigned to reflect the overall impact the practice has on the environment. A secondary rank associated each practice with its impact on each of seventeen environmental issues common to the agriculture sector (Eilers et al. 2010). Having two types of ranks allowed me to acknowledge that some practices are beneficial for some environmental issues, but detrimental for others (Gitau et al. 2005) and still arrive at an overall rank for that issue that could be used in further calculations. For example, zero tillage is considered a beneficial practice because it can reduce erosion and nutrient loss and increase soil organic carbon. However, in a wet climate zero tillage can also lead to denitrification and the emission of nitrous oxide, a potent greenhouse gas. In most cases, the benefits of zero tillage outweigh the negative impacts and therefore it is considered a beneficial practice and assigned an overall rank of five. I considered each practice separately and considered the practice's influence on each environmental issue – supported by literature and expert opinion - before arriving at the overall ranking. The rankings for each of the practices included in the Index are presented in Appendix 3. Supporting documentation for the rankings is provided in Appendix 4.

I determined the rankings in two ways. First, I conducted a literature search for each practice with the objective of determining its efficacy in terms of overall environmental impact, and identifying the environmental issues which are impacted directly by the practice. I found that this information is often lacking and, when information is available, it is often not well synthesized across issues and regions. Others have attempted similar exercises and have come to the same conclusion (Lewis and Bardon 1998, Filson et al. 2009, Gitau et al. 2005, Smiley et al. 2009, Sattler et al. 2010, Liu 2007). Where literature was unavailable, or where it presented conflicting perspectives, I used expert opinion to determine the rankings. Research scientists and other technical experts from AAFC who have in-depth knowledge of farm management practices and could identify the rankings based on local knowledge and experience were consulted. This approach has been used by others in lieu of more quantifiable data (Lewis and Bardon 1998, Valentin et al. 2004). A list of people consulted is found in Appendix 5.

BMP Adoption Index calculation

I calculated the BMP Adoption Index using the following steps: First, I applied overall rankings as described above to each of the practices indicated in each data record. Second, I grouped together the practice options under each of the FEMS questions. For example, for the question 'what area was prepared prior to planting using each of the following practices?' the three options, 'conventional tillage, conservation tillage, no-till/zero till' were grouped together under the heading 'tillage practices'. I summed the practices within each grouping using the formula:

$$\text{Question grouping score} = \sum (\text{practice x overall ranking})$$

This method is similar to that applied by Lewis and Bardon (1998) and Taylor et al. (1993). Three types of practices were summed differently as described in McDonald and Glynn (1994): ‘Integrated pest management practices’, ‘practices to control pesticide drift’ and ‘practices to reduce amount of pesticide used’. Literature research and expert opinion suggest that each of these practice options are relatively equal in efficacy, and become more effective as more of them are implemented. To accommodate for this, I calculated the score by summing the number of practices implemented.

I then normalized each question grouping by dividing the scores by the maximum score in the grouping so that each group would have a consistent score and have equal weight in the final BMP adoption score. The normalized scores for each grouping were summed for each respondent:

$$\text{BMP adoption} = \sum \text{normalized groupings}$$

Not all practices are applicable to all producers. For example, a potato farmer cannot implement no-till, and a producer with no wetlands or waterways cannot implement water management BMPs. To ensure the BMP Adoption score is accurate and relevant for each producer, I counted the number of question groupings that were deemed to be not applicable to a particular respondent. I finally calculated the BMP Adoption Index score by using the formula:

$$\text{BMP Adoption Index Score} = \frac{\sum \text{normalized scores for each grouping}}{\text{total number of groupings} - \text{‘not applicable’}}$$

I could then calculate the average BMP adoption score for any set of producers or any ecoregion or province as needed.

BMP Adoption Index maps

I produced four types of maps to present the results of the BMP Adoption Index, using ArcGIS 9.3 (ESRI): First, I produced maps presenting the average BMP Adoption Index scores for each of the 27 ecoregions. The scale for these maps range from the highest average BMP

Adoption score to the lowest average score in the data set so the maximum amount of variability between regions would be apparent on each map.

For the second type of map, I calculated average BMP Adoption by issue to show the percentage of soil quality, water quality, air quality and biodiversity BMPs adopted for all farms, crop producers and livestock producers in each ecozone-ecoregion. I calculated these values by first identifying the total number of BMPs that address each of the four issues (Table 3). Only those practices that have a direct positive impact on an issue were considered; these were the practices whose secondary rankings were four or five in the table in Appendix 3. Next, I determined how many BMPs for each issue were adopted for each data record, considering those practices that were not applicable to some producers based on their particular circumstance. The maximum number of practices that were relevant for each respondent for each issue was different, so I calculated the average number of relevant practices for the region. Lastly, I calculated the level of BMP adoption for each issue area in each region by dividing the average number of BMPs adopted for each issue by the average number of applicable practices for each issue in the region. The result was presented as a percentage of the total number of practices that were adopted for each issue area. I identified a scale of low, medium and high adoption for the average BMP adoption of each issue area and applied it to each of the maps. The scale was determined by identifying the highest and the lowest percent adoption across all issues, and dividing this range into three equal parts. Low adoption is 8-17%, medium adoption is >17-27% and high adoption is >27-37%.

The third map type I created presents the risk of agriculture to soil, water, air and biodiversity in agricultural areas in Canada. I created these maps by applying AAFC's Agri-Environmental Performance Index (Eilers et al, 2010), which aggregates the results of AAFC's agri-environmental indicators to the ecozone-ecoregion scale for each issue. The Index is unit-less and ranges from 0-100 where 0-20 is very low performance, 21-40 is low performance, 41-60 is moderate performance, 61-80 is high performance, and 81-100 is very high performance (desired state). The maps present three risk classes: low, medium and high. I modified the classes of the

Agri-Environmental Performance Index as follows: the low class is made up of the very low and low risk classes (0-40), the medium risk class is made up of the moderate class (41-60), and the high risk class is made up of the high and very high risk classes (61-100).

Lastly, I created maps that related the average adoption of BMPs that address problems related to soil, water, air and biodiversity to the level of environmental risk by overlaying the data from the two types of maps. This resulted in maps that present 9 combinations of risk and adoption ranging from high risk, high adoption to low risk, low adoption. Maps were created for all farms, crop farms and livestock farms for each issue area.

RESULTS

Overall BMP adoption in Canada

Average BMP adoption by all producers across Canada in 2006 range from 25.1% to 41% of the maximum number of BMPs that are applicable to each farm (Figure 2). The Prince Edward Island ecoregion has the highest average BMP adoption in Canada, with farmers implementing, on average, 36% of the total possible BMPs that can be implemented in their region. Other high adopting ecoregions included the St. Lawrence Lowland ecoregion in Quebec where farmers are adopting 34.5% of the total BMPs that can possibly be implemented, and the Lake Erie Lowland and St. Lawrence Lowland ecoregions in Ontario which both are implementing an average of 34.2% of possible BMPs. The highest individual BMP adoption score by a farmer is within the St. Lawrence Lowland region in Ontario, who is implementing 71% of the total possible BMPs. The lowest average adoption values are located in the Montane Cordillera and Boreal Plains ecoregions in British Columbia.

BMP Adoption by Crop Producers

Prince Edward Island has the highest average BMP Adoption score for crop producers (40%, Figure 3). BMP adoption by crop producers is also high in the St. Lawrence Lowlands ecoregions in both Quebec and Ontario, in southwestern Ontario, and in southern Manitoba, Saskatchewan and Alberta. The Boreal Plains ecoregion in north eastern British Columbia has the lowest average adoption (24%) by crop farmers. The crop farmer with the highest individual BMP adoption score (68%) is located in Prince Edward Island.

BMP Adoption by Livestock Producers

Prince Edward Island has the highest average BMP Adoption score for livestock producers (31.9%), followed by the Gaspe region in Quebec with a score of 31.1% (Figure 4). The highest scoring livestock farmer in Canada is located in the Montane Cordillera ecoregion in Alberta, with an adoption score of 59% of the total possible BMPs that can be implemented. The average scores for livestock producers are markedly lower than the average adoption scores of crop producers, and slightly lower than the average adoption scores for all producers. The lowest average BMP adoption scores by livestock producers in Canada are in Saskatchewan, most of Alberta, and parts of Manitoba and British Columbia.

BMP adoption to manage risk to soil quality

The risk to soil quality by agriculture map (Figure 5) presents the soil Agri-Environmental Performance Index which integrates the results for the risk to soil by wind, water and tillage erosion indicators, the soil organic carbon indicator, the risk of soil salinization indicator (Alberta, Saskatchewan and Manitoba only) and the soil cover indicator for 2006 (Eilers et al, 2010). Soil quality is at low risk in the Prairie Provinces, New Brunswick and Nova Scotia, high risk on the west coast of British Columbia, and moderate risk in the rest of the country.

Average adoption of soil quality BMPs by all producers is high in Prince Edward Island and medium or low in the rest of the country (Figure 6). Crop producers in Saskatchewan, southern Manitoba and most of Alberta have medium adoption, as well as southwestern Ontario, southern Quebec and Prince Edward Island while crop producers in other regions have low adoption (Figure 7). Average adoption of BMPs to address soil quality by livestock producers is medium with a few notable exceptions (Figure 8). Prince Edward Island has high adoption by livestock producers, while the Lake Erie Lowland region of Ontario and the Dark Brown Soil Zone region in Saskatchewan have low adoption. Average adoption of soil BMPs by livestock producers across Canada is somewhat higher than average adoption of BMPs to address soil problems by crop producers. Livestock producers have fewer regions with low adoption than crop producers (2 regions vs. 12 regions) and have more regions with high adoption than crop producers (1 vs 0).

When comparing the risk to soil quality to the adoption of soil quality BMPs by all producers (Figure 9), Prince Edward Island is the one region with higher adoption relative to the risk level. Five regions have low adoption of soil quality BMPs and of these, the Pacific Maritime region of British Columbia may be a concern since risk to soil quality is high. For crop producers, there are no ecoregions with high adoption of soil quality BMPs even though twelve ecoregions have medium or high risk (Figure 10). For livestock producers , twenty-four of the twenty-seven regions across the country show medium adoption of soil quality BMPs, fourteen of which have low risk (Figure 11). The three ecoregions that don't have medium risk are Prince Edward Island which has higher average adoption relative to the level of risk, the Lake Erie Lowland region in southwestern Ontario that has lower adoption relative to the level of risk, and the Dark Brown Soil Zone ecoregion in Saskatchewan that has low adoption in an area with low risk.

BMP adoption to manage risk to water quality

The risk to water quality by agriculture is calculated from the water Agri-Environmental Performance Index and includes the results of the risk to water quality by nitrogen, phosphorus and pesticides indicators (Eilers et al, 2010). There is a large regional variation in the risk to water quality from west to east, with low risk in all provinces west of Ontario, moderate risk in Ontario, Quebec and Nova Scotia, and high risk in New Brunswick, Prince Edward Island and Newfoundland and Labrador (Figure 12).

The average adoption of BMPs to improve water quality by all producers varies between the eastern and western parts of the country, with the east having mostly high adoption and the west having mostly medium adoption (Figure 13). Considering all producers, no ecoregions in Canada have low average adoption of water quality BMPs. There are also no ecoregions where crop producers show low adoption of water quality BMPs (Figure 14). The adoption of water quality BMP adoption by livestock producers shows regional variation. The western provinces have medium and low adoption, Ontario and Quebec mostly have high adoption except for one region in Ontario which has low, and the Atlantic Provinces all have medium adoption except for Prince Edward Island, which has high adoption (Figure 15).

When looking at the relationship between risk to water quality and adoption of water quality BMPs by all producers, the three regions that show high risk to water quality have medium (Newfoundland and Labrador, New Brunswick) or high (Prince Edward Island) adoption (Figure 16). The pattern is similar for the adoption of water quality BMPs by crop producers although in this case two regions have high adoption and one has medium (Figure 17). The two extremes can be seen in the average water quality BMP adoption by livestock producers: high risk and high adoption is seen in Prince Edward Island, and low risk, low adoption occurs in northern Saskatchewan (Figure 18). Of the eleven ecoregions where there is medium or high risk to water quality, livestock producers have high adoption of water quality BMPs in seven of them.

BMP adoption to manage risk to air quality

The risk to air quality by agriculture is calculated from the air quality Agri-Environmental Performance Index and includes the results of the indicators for risk to air quality by agricultural greenhouse gas emissions, ammonia emissions and primary particulate matter emissions (Eilers et al, 2010). Air quality risk from agriculture is high in southwestern Ontario, western Quebec, and Prince Edward Island while the rest of the country has medium or low risk (Figure 19).

Air quality BMP adoption by all producers is mostly medium with the exception of Prince Edward Island and some Prairie Regions which are high (Figure 20). In all regions crop producers have medium and high average adoption of air quality BMPs (Figure 21). Adoption of air quality BMPs by livestock producers is quite different from crop producers in that all regions have medium or low average adoption of air quality BMPs (Figure 22).

When looking at the relationship between BMP adoption and risk to air quality for all producers, most of the regions have medium adoption for low, medium and high levels of risk except Prince Edward Island which has high average adoption and high risk (Figure 23). For crop producers, Prince Edward Island and the Lake Erie Lowland region in Ontario show high risk and high average adoption of air quality BMPs, and all 8 regions with medium risk in the Prairies show high average adoption of air quality BMPs (Figure 24). Livestock producers have two regions where there is high risk and low average adoption of air quality BMPs, and 7 regions with low adoption and medium risk which may be cause for concern (Figure 25).

BMP adoption to manage risk to biodiversity

The risk to biodiversity by agriculture is an adaptation of the Wildlife habitat capacity on agricultural lands in Canada indicator (Eilers et al, 2010). There are large regional differences across the country, with Nova Scotia, New Brunswick and parts of Quebec having low risk, and southern Ontario, western Quebec and the western provinces with high risk to biodiversity (Figure 26).

The adoption of biodiversity BMPs by all producers is mostly medium across the country with the exception of 2 regions (Figure 27). Crop producers' adoption of biodiversity BMPs are a bit more varied but still are mostly medium and low (Figure 28). Adoption of biodiversity BMPs by livestock producers is also quite variable across the country however there are many more regions with high adoption (11) (Figure 29).

When looking at the relationship between average adoption of biodiversity BMPs by all producers and risk to biodiversity, the two regions that have high adoption are in regions that have high risk which is positive (Figure 30). For crop producers only one region with high risk has high adoption (Prince Edward Island), and two regions with high risk have low adoption, which may be a concern (Figure 31). The relationship between risk to biodiversity and adoption of biodiversity BMPs by livestock producer is quite different in that more regions show high levels of biodiversity BMP adoption than crop producers (11 vs. 1), and 9 of these occur in regions with high risk (Figure 32).

Cross-issue comparison

Adoption of BMPs by all producers largely falls in the medium and high adoption ranges (Figures 6, 13, 20, 27). Only three regions have the same level of adoption for all four issues; Prince Edward Island had high adoption across all issues, and the Dark Brown Soil Zone ecoregion in Saskatchewan and Montane Cordillera in Alberta had medium adoption of BMPs to address all four issues. Five regions have low adoption by all producers for at least one of the issues. Two of these, the Boreal Shield ecoregion in Quebec and the Pacific Maritime ecoregion in British Columbia have low BMP adoption for more than one issue.

Average BMP adoption for all issues by crop producers is also variable. Only Prince Edward Island has the same level of adoption (high) for all four issues. (Figures 7, 14, 21, 28). Twelve ecoregions have low average adoption in at least one issue area; four of these have low adoption in two issue areas. However, these regions also have high adoption in at least one other issue area. Only BMP adoption for soil quality and biodiversity was low; BMP adoption for water quality and air quality were medium or high

Average BMP adoption by livestock producers show four ecoregions where the level of adoption was the same across all four issue areas. The Lake Erie Lowland ecoregion in Ontario and the Dark Brown Soil Zone in Saskatchewan both have low BMP adoption for the four issue areas, and the Lake Manitoba Plain region in Manitoba and Brown Soil Zone in Alberta both have medium adoption for each of the issues. Eight ecoregions have low adoption in at least one of the four issue areas, one of which showed low adoption in two issue areas. Five of these regions showed high adoption in at least one other issue area, however.

DISCUSSION

The results reveal that average BMP adoption in most Canadian ecozone-ecoregions is medium, regardless of the environmental issues facing the area or the level of environmental risk. This suggests that BMP adoption is not being driven by a particular environmental issue or risk, and that something else must therefore be the key factor driving BMP adoption.

Many studies have been undertaken to identify drivers of BMP adoption. Some of the most common drivers include regulation (Robinson 2006), financial incentives and programs (OECD 2006), compliance to avoid regulation (Prokopy 2008), access to information about adoption (Feather and Amacher 1994), and desire to be perceived as being a good steward by peers (Prokopy 2008). Other studies have identified education and farmer's age as drivers but these appear to be less influential than others (Knowler and Bradshaw 2007). The conclusion of most of these studies is that BMP adoption is economically driven and scale dependent and that therefore, universal drivers are difficult to identify. However, several patterns emerge from the results of my study that may help clarify some of the drivers of BMP adoption in Canada.

First, there is relatively higher overall adoption in regions with high agricultural activity than in those with less intensive agriculture. Agriculture is a dominant land use in southern Alberta and Saskatchewan, southeastern Manitoba, southwestern Ontario, southern Quebec and Prince Edward Island (Figure 33). There may be a number of reasons why BMP adoption is higher in these areas. Regions where agriculture is a dominant land use are likely to be targeted for agri-environmental programs and policies by all levels of government to manage risk to the environment (AAFC 2010). Producers in these regions may also have better access to information and resources to help them increase adoption because they are targeted by governments and non-governmental organizations interested in agriculture. As well, these areas have a well established community and network of peers which may influence adoption.

Second, there is higher adoption where the environmental history of the region is strongly influenced by a particular issue. For example, the Prairie Provinces have low risk to soil quality, water quality and air quality and yet have medium adoption for all types of BMPs. In the 1930s in this region, soil erosion was a major environmental issue that posed risk to the financial viability of farmers (Tarnoczi and Berkes 2010). At that time, BMPs were promoted to reduce erosion and retain soil moisture to improve the health of the soil so it would continue to remain productive. As a result, farmers implemented soil quality BMPs to restore soil health (which is reflected in Figure 5). Given this past experience, programs to encourage BMP adoption to maintain soil quality are well established and information on the benefits of BMPs are widely available, and it is likely that farmers in these regions will continue to implement these practices even though risk to soil health is low.

BMP adoption may also be driven by the level of environmental regulation. For example, Prince Edward Island (PEI) is the one region in Canada where both BMP adoption and risk is high for most environmental issues. The high adoption is likely driven by the high level of environmental regulation that farmers are subject to in this region (Jatoe et al. 2008). Strict regulations exist in this province for soil erosion management, setback distances for water quality, livestock management and manure storage and spreading (PEI DA 2010). This region also has a high density of agriculture and widely available information about BMPs, two of the factors already discussed that can influence BMP adoption.

Finally, many BMPs provide multiple benefits and have a positive influence on more than one environmental issue, which may explain the high level of BMP adoption for some of the issues. Producers may adopt a BMP to mitigate a specific problem on their farm, and end up providing benefits in several areas. This can be especially true for biodiversity – many grazing management, water quality and soil quality BMPs enhance habitat capacity and therefore also benefit biodiversity – and may explain why BMP adoption for biodiversity is high in some regions. The results show that BMP adoption for biodiversity is mostly medium, however livestock producers show more regions with high adoption than crop producers, likely because of grazing management practices being implemented that provide a co-benefit to biodiversity. Many soil conservation and water quality BMPs provide benefits to biodiversity as well (Table 3)

Policy implications and future research

These results can be used to inform agri-environmental policy and program development and to identify areas where more research may be required. In areas where BMP adoption is low, decision-makers can now choose to target regions to increase adoption, can decide whether to focus efforts on mitigating areas that have high risk, or can prioritize areas that require mitigation based on the combination of adoption and risk. Policy makers may use this tool to identify areas with high BMP adoption and learn from this success, or identify areas of low adoption and realize gaps in programming. This information may also be used to evaluate the success of programs that have been established to increase uptake of BMPs. As AFDdfljasldfjIdentifying trends of BMP adoption over time can also help assess the effectiveness of agri-environmental programs and policy. Integrating BMP data from other sources or from the 2001 FEMS survey can enhance the BMP Adoption Index data set to better understand adoption patterns.

Further refinement of this tool can allow for even more robust analysis of BMP adoption. For example, more detailed information on risk to the environment would allow the analysis to be targeted at a finer scale than the ecozone-ecoregions used in this study. As well, refining the results to identify specific crop or livestock types can give a more accurate picture of BMP adoption that allows more targeted analysis. Further research on BMP efficacy and how it may vary across regions (i.e. eastern and western Canada), and considering cumulative benefits and antagonistic relationships of different BMPs would enhance the accuracy of the tool and allow more detailed analysis for policy development. Additionally, combining BMP adoption scores with socio-economic information can facilitate analysis to better understand the characteristics of producers who demonstrate high or low adoption. By integrating this information with the BMP Adoption Index it may be possible to determine whether education level, income and size of farm for example, influence the level of BMP adoption in particular regions. This more detailed understanding can help target policies and programs in order to increase adoption of BMPs and mitigate risk to the environment.

Limitations

The results of this study must be interpreted with caution. The BMP Adoption Index is a macro-level indicator that presents the average value of BMP adoption for each region across Canada. Within each ecoregion, there are producers that are implementing more BMPs and those that are implementing less and the BMP Adoption Index should not be considered the final authority on whether farms are being managed appropriately. The BMP Adoption Index alone does not determine the sustainability of agriculture; this can only be assessed by considering BMP adoption with more detailed data such as climate, soil type, inputs applied, surrounding landscape, as well as, of course, measurements of the actual effect of farming practices on the environment.

The BMP rankings introduced to calculate the BMP Adoption Index are based on literature where available and on expert opinion, and largely reflect the most current science on these practices. However, integrating ranking and weightings adds an element of subjectivity to the indicator and therefore an inherent uncertainty. As knowledge about farm practices evolves, the rankings may be altered, resulting in different findings. Applying a ranking scheme to the management practices to calculate the BMP Adoption score is a value-dependent process and increases the uncertainty of the analysis however, in absence of a quantitative, research-based alternative, this provides a starting point to conduct analysis on BMP adoption where there was no information previously (Carpenter et al. 2009). The rankings have been vetted by AAFC research scientists and technical experts and reflect the current science and departmental priorities. As such, the subjectivity that is inherent in assigning ranking values is considered acceptable to suit the purposes and goals of the research. Given the uncertainty however, the tool will benefit from a sensitivity analysis that tests different ranking conventions to ensure the robustness of the results.

Limitations with the data include the spatial scale at which the data was collected and quality of the survey responses. The survey size and cost dictated the scale at which the data was collected and therefore analysis at finer scales is not possible. This limits the amount of information that can be provided by the BMP Adoption Index and allows only for broad scale assessments to be made. Data available at a smaller scale would be valuable. Statistics Canada takes the utmost care in ensuring data quality when conducting surveys, however the data is only as accurate as the honesty of the respondents participating and therefore some level of error is assumed to exist.

CONCLUSION

The results of this study identify the level of BMP adoption across Canada and suggests that the level of BMP adoption is not influenced by environmental risk or by a specific environmental issue. This is the first attempt to aggregate this information into a form that can communicate overall adoption for all issues across Canada. It can now be used as a stand-alone indicator that provides a snapshot of BMP Adoption, and provides a descriptive analysis of how farms in Canada are being managed at a broad scale. It can be disaggregated into smaller components (such as major farm type, region, environmental issue) in order to conduct more specific analysis, which makes it a valuable tool for policy research. The information generated by this study can be used to inform policy and program development, and to evaluate the success of current programming on increasing BMP adoption.

Environmental Issue	Indicator
Soil quality	Soil Cover
	Risk of soil erosion (wind, water, tillage)
	Soil organic carbon change
	Risk of soil salinization (prairies only)
	Risk of soil contamination by trace elements
Water quality	Indicator of risk of water contamination by nitrogen
	(IROWC-N) -linked to Residual Soil Nitrogen
	Indicator
	Indicator of risk of water contamination by phosphorus (IROWC-P
	Indicator of risk of water contamination by coliforms (IROWC-Coll)
	Indicator of risk of water contamination by pesticides (IROWC-pest)
Air quality	Agricultural greenhouse gas budget
	Ammonia emissions from agriculture
	Agricultural particulate matter emissions
Biodiversity	Wildlife habitat on farmland

TABLE 1: Environmental issues and indicators reported on by Agriculture and Agri-Food Canada. The indicators measure risk to the environment by agriculture for each of the issues below using models that integrate biophysical characteristics of the landscape and land use activities. The results provide an assessment of the environmental performance of the agriculture sector.

Rank	Definition
1 - worst practice	This class indicates non-active management, or management options that directly contribute to environmental degradation or worsening condition including pollution, contamination, degradation, loss or destruction of air, water, soil or biodiversity. Not an acceptable practice for any operation.

2 - poor practice	Indicates that some management is taking place, however the practice is not sustainable over time and is considered a minimal effort to managing an issue and reducing impact or risk or improving condition. This practice will likely lead to environmental degradation over time and may directly or indirectly result in pollution, contamination, degradation, impairment, loss or destruction. Minimal benefits, if any, are generated by this practice and these benefits are mostly outweighed by the negative impacts. May be an acceptable option in some situations however overall it provides little or no benefit to air quality, water quality, soil quality or biodiversity.
3 – acceptable/average practice	A practice in this class may provide some benefits to mitigate risk or improve the condition of the environmental issue. This practice does not typically contribute to improved condition of the issue, but does not contribute to its degradation either. Using this practice over time will neither impact the issue in an overall negative or positive way. This practice may contribute to improved condition of some aspects of air, water, soil or biodiversity, but may impact some other aspects in a negative way, which offsets or neutralize the positives. This class acknowledges that active management is taking place, however there are likely better management options available.
4 – beneficial practice	Implementing this practice will likely result in improved condition or reduced risk of the issue over time. This practice may benefit some issues and may adversely affect others, however the positive impacts outweigh any negative impacts. While there may be better options available, implementing this practice will contribute to a sustainable operation.
5 – optimal practice	This practice improves environmental condition or minimizes environmental risk and prevents contamination, pollution, or worsening of condition. This practice also provides environmental benefits, which is what distinguishes an optimal practice from a beneficial practice. Implementation will result in sustainability of the operation. While no practice is perfect, the positive impacts generated by this practice largely outweighs any negative impacts this practice may have.

TABLE 2: Ranking definitions for practices included in the BMP Adoption Index. Rankings determine the efficacy of the farm practices in mitigating environmental risk and providing benefits to the environment. Rankings are adapted from Lefebvre et al. 2005.

TABLE 3: BMPs included in analysis of BMP adoption by environmental issue. Some BMPs appear under more than one issue since they provide multiple benefits to the environment.

Environmental Issue	BMPs
Soil Quality	Conservation tillage No till/zero till Practice crop rotation Crop residues left on ground Chop and spread crop residues Spread residues without chopping Soil testing every year Solid manure tested for nutrient content before application Solid manure broadcast and incorporated Liquid/semi-solid manure tested for nutrient content before Application Liquid/semi-solid manure broadcast and incorporated into the soil Liquid/ semi solid manure directly injected into the soil Plant green manure or cover crops Plant in the fall Use covers or mulches Cover or companion crops seeded Winter cover or green manure crops seeded alone after previous crop harvest Strip cropping used Permanent perennial forages planted on erodible land Straw mulching spread on erodible land Farmstead shelterbelts/windbreaks established Field shelterbelts planted GPS used for collecting information for soil and crop mgmt Practice rotational grazing Pasture seeded every 1-2 years Pasture seeded every 3-5 years Extend grazing season by using forages that grow in early spring Extend grazing season by using forages that grown in late fall
Water quality	Conservation tillage No till/zero till Crop residues left on ground Chop and spread crop residues Spread residues without chopping Fertilizer applied with seed Fertilizer applied by subsurface application separate from seeding Fertilizer applied by subsurface application during seeding in a separate band away from seed Fertilizer applied by surface broadcast and incorporated Soil testing every year Quantity of fertilizer reduced due to manure application

	Fertilizer applied before seeding, or before new growth begins Fertilizer applied after seeding, before harvest or after new growth begins Solid manure tested for nutrient content before application Solid manure applied before crop growth Solid manure applied after crop growth began Solid manure broadcast and incorporated Solid manure incorporated same day as application Solid manure incorporated 1-2 days after application Liquid/semi-solid manure tested for nutrient content before application Liquid/semi-solid manure applied before crop growth Liquid/semi-solid manure applied after crop growth began Liquid/semi-solid manure broadcast and incorporated Liquid/semi-solid manure directly injected into the soil Liquid/semi-solid manure incorporated same day as application Liquid/semi-solid manure incorporated 1-2 days after application Controlled pesticide drift by applying pesticides only when winds are below recommended thresholds Controlled pesticide drift by using low drift or low pressure nozzles Controlled pesticide drift by using shrouded booms Controlled pesticide drift by adding anti-drift agents or chemicals Controlled pesticide drift by leaving untreated buffer zones Plant green manure or cover crops Plant in the fall Cover or companion crops seeded Winter cover or green manure crops seeded alone after previous crop harvest Strip cropping used Planting permanent perennial forages on erodible land Straw mulching spread on erodible land Maintaining a riparian buffer along seasonal wetland, permanent wetland and waterways Maintaining a setback distance along seasonal wetland, permanent wetland and waterways GPS used for collecting information for water management GPS used for targeting or varying fertilizer or manure application rate Storage capacity of liquid/semi-solid manure storage system: 251+ days Solid manure pile on ground on impermeable pad Solid manure pile on ground has runoff containment system Manure pack in barn or corral on impermeable pad

	Manure pack in barn or corral has runoff containment system Practice rotational grazing Extend grazing season by using forages that grow in early spring Extend grazing season by using forages that grow in late fall Grazing livestock have no access to surface water Livestock access to surface water is restricted by fencing shoreline Livestock access to surface water is restricted through remote or off-site watering system to a trough
Air quality	No till/zero till Fertilizer applied with seed Fertilizer applied by subsurface application separate from seeding Fertilizer applied by subsurface application during seeding in a separate band away from seed Fertilizer applied by surface broadcast and incorporated Solid manure surface broadcast and incorporated Solid manure incorporated same day as application Solid manure incorporated 1-2 days after application Liquid/semi-solid manure broadcast and incorporated into the soil Liquid/semi-solid manure directly injected into the soil Liquid/semi-solid manure incorporated same day as application Liquid/semi-solid manure incorporated 1-2 days after application Controlled pesticide drift by applying pesticides only when winds are below recommended thresholds Controlled pesticide drift by using low drift or low pressure nozzles Controlled pesticide drift by using shrouded booms Controlled pesticide drift by adding anti-drift agents or chemicals Controlled pesticide drift by leaving untreated buffer zones Permanent perennial forages planted on erodible land Farmstead shelterbelts/windbreaks established Field shelterbelts planted Livestock building air quality managed by forced ventilation with filter on exhaust fans Livestock building air quality managed by forced ventilation, no filter Livestock building ventilation rate controlled by fans switched on automatically Livestock building ventilation rate controlled by fans switched on manually Exhaust fan filter changed every month Exhaust fan filter changed every 2-5 months Liquid/semi-solid manure system is covered Cover on liquid/semi-solid manure system is lid Cover on liquid/semi-solid manure system is tarp Solid manure pile on ground has roof or cover Solid manure in manure pack or corral has roof or cover Livestock sheltering sites are moved to different locations in an open feeding area

Biodiversity	No till/zero till Crop residues left on ground Chop and spread crop residues Crop residues spread without chopping Plant green manure or cover crops Plant in the fall Use covers or mulches Cover or companion crops seeded Winter cover or green manure crops seeded alone after previous crop harvest Permanent perennial forages planted on erodible land Straw mulching on erodible land Farmstead shelterbelts/windbreaks established Field shelterbelts planted Maintaining a riparian buffer around seasonal wetland, permanent wetland or waterway Extend grazing season by using forages that grow in early spring Extend grazing season by using forages that grow in late fall

FIGURE CAPTIONS

Figure 1: This figure presents the 27 modified ecozone-ecoregions used to spatially stratify the sample for the Farm Environmental Management Survey (FEMS).

Figure 2: This figure presents the average BMP Adoption Index score for each of the ecozone-ecoregions across Canada. The scale ranges from the lowest BMP Adoption Index score calculated for an individual to the highest (identified by a star in region 8).

Figure 3: This map presents the average BMP Adoption Index score for crop producers in each of the 27 ecozone-ecoregions in Canada. The scale ranges from the lowest BMP Adoption Index score calculated for an individual to the highest (identified by a star in region 8).

Figure 4: This map presents the average BMP Adoption Index score for livestock producers in each of the 27 ecozone-ecoregions in Canada. The scale ranges from the lowest BMP Adoption Index score calculated for an individual to the highest (identified by a star in region 22).

Figure 5: This map presents the results of Agriculture and Agri-Food Canada's Soil Quality Agri-Environmental Performance Index which integrates the results for the indicators of soil cover, soil organic matter, soil salinity and soil erosion by wind, water and tillage. The performance index ranges from 0 (poor performance) to 100 (high performance). Low risk is defined as 61-100, Medium risk is 40-60 and High risk is defined at 0-40.

Figure 6: This figure presents the average adoption of soil quality BMPs by all producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 7: This figure presents the average adoption of soil quality BMPs by crop producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest

average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 8: This figure presents the average adoption of soil quality BMPs by livestock producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 9: This figure associates the average soil quality BMP adoption by all producers with the level of risk to soil quality. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 10: This figure associates the average soil quality BMP adoption by crop producers with the level of risk to soil quality. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 11: This figure associates the average soil quality BMP adoption by livestock producers with the level of risk to soil quality. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 12: This map presents the results of Agriculture and Agri-Food Canada's Water Quality Agri-Environmental Performance Index which integrates the results for the indicators of risk to water contamination by nitrogen, phosphorus and pesticides. The performance index ranges from 0 (poor performance) to 100 (high performance). Low risk is defined as 61-100, Medium risk is 40-60 and High risk is defined at 0-40.

Figure 13: This figure presents the average adoption of water quality BMPs by all producers for

each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 14: This figure presents the average adoption of water quality BMPs by crop producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 15: This figure presents the average adoption of water quality BMPs by livestock producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 16: This figure associates the average water quality BMP adoption by all producers with the level of risk to water quality. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 17: This figure associates the average water quality BMP adoption by crop producers with the level of risk to water quality. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 18: This figure associates the average water quality BMP adoption by livestock producers with the level of risk to water quality. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 19: This map presents the results of Agriculture and Agri-Food Canada's Air Quality Agri-Environmental Performance Index which integrates the results for the indicators of agricultural greenhouse gas emissions, agricultural ammonia emissions and agricultural particulate matter emissions. The performance index ranges from 0 (poor performance) to 100 (high performance). Low risk is defined as 61-100, Medium risk is 40-60 and High risk is defined at 0-40.

Figure 20: This figure presents the average adoption of air quality BMPs by all producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 21: This figure presents the average adoption of air quality BMPs by crop producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 22: This figure presents the average adoption of air quality BMPs by livestock producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 23: This figure associates the average air quality BMP adoption by all producers with the level of risk to air quality. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 24: This figure associates the average air quality BMP adoption by crop producers with the level of risk to air quality. The map presents 9 combinations of risk (high, medium, low) and

adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 25: This figure associates the average air quality BMP adoption by livestock producers with the level of risk to air quality. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 26: This map presents the results of Agriculture and Agri-Food Canada's Biodiversity Agri-Environmental Performance Index which represents the results for the Wildlife Habitat Capacity on farmland indicator. The performance index ranges from 0 (poor performance) to 100 (high performance). Low risk is defined as 61-100, Medium risk is 40-60 and High risk is defined at 0-40.

Figure 27: This figure presents the average adoption of biodiversity BMPs by all producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 28: This figure presents the average adoption of biodiversity BMPs by crop producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 29: This figure presents the average adoption of biodiversity BMPs by livestock producers for each ecozone-ecoregion and is calculated as the percentage of BMPs adopted. The scale range is consistent for all maps that show issue-specific adoption. The scale is defined by the lowest average BMP adoption to the highest for the four environmental issues. Low, medium and high adoption were determined by dividing the range into three equal parts.

Figure 30: This figure associates the average biodiversity BMP adoption by all producers with the level of risk to biodiversity. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 31: This figure associates the average biodiversity BMP adoption by crop producers with the level of risk to biodiversity. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 32: This figure associates the average biodiversity BMP adoption by livestock producers with the level of risk to biodiversity. The map presents 9 combinations of risk (high, medium, low) and adoption (high, medium, low) and the legend indicates the number of ecozone-ecoregions in each combination.

Figure 33: This figure presents the percentage of land where agricultural activities are present by Soil Landscape of Canada (SLC) polygon (Eilers et al. 2010).

Figure 1: FEMS 2006 geographies

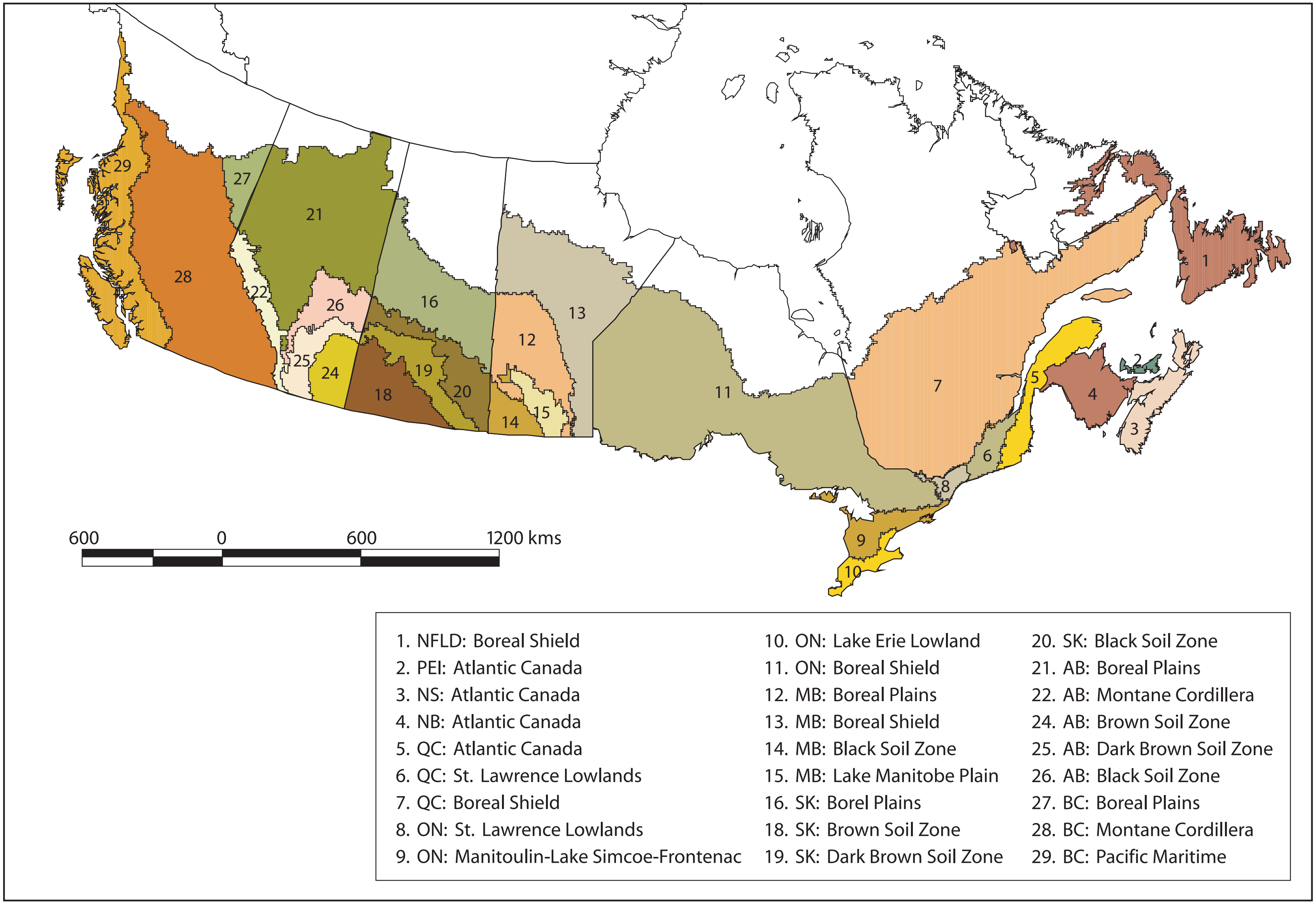


Figure 2: BMP adoption by all producers in Canada

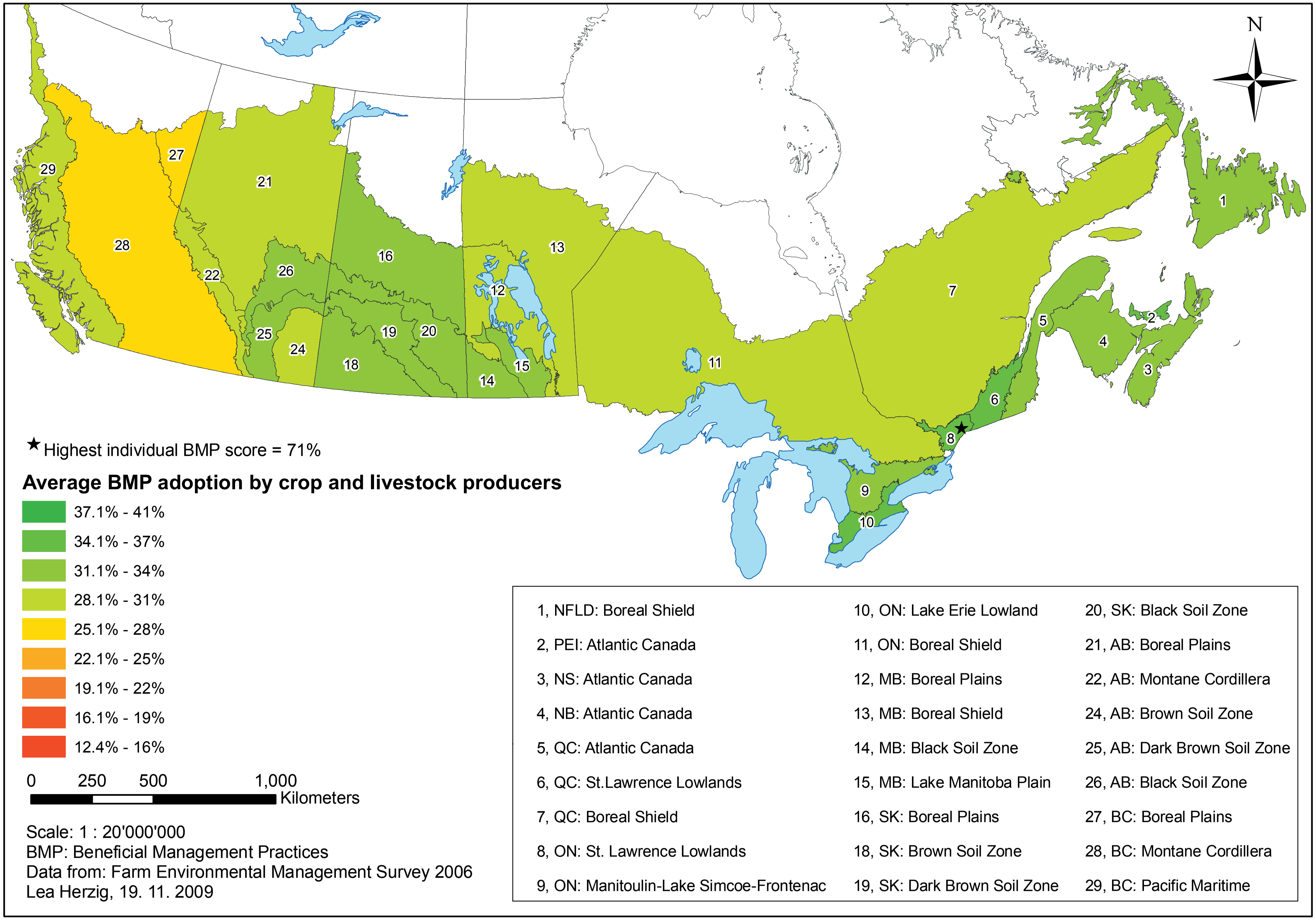


Figure 3: BMP adoption by crop producers in Canada

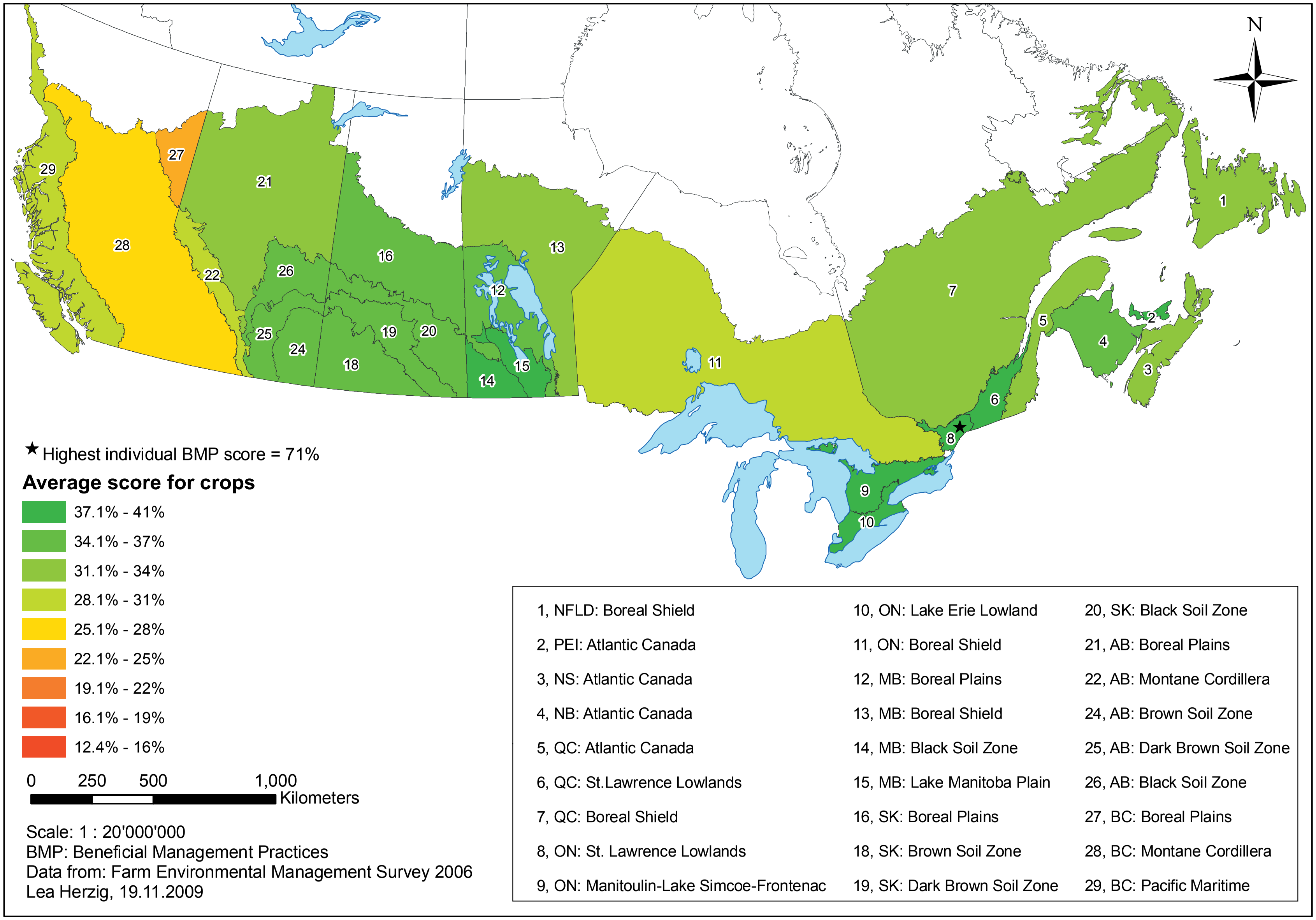


Figure 4: BMP adoption by livestock producers in Canada

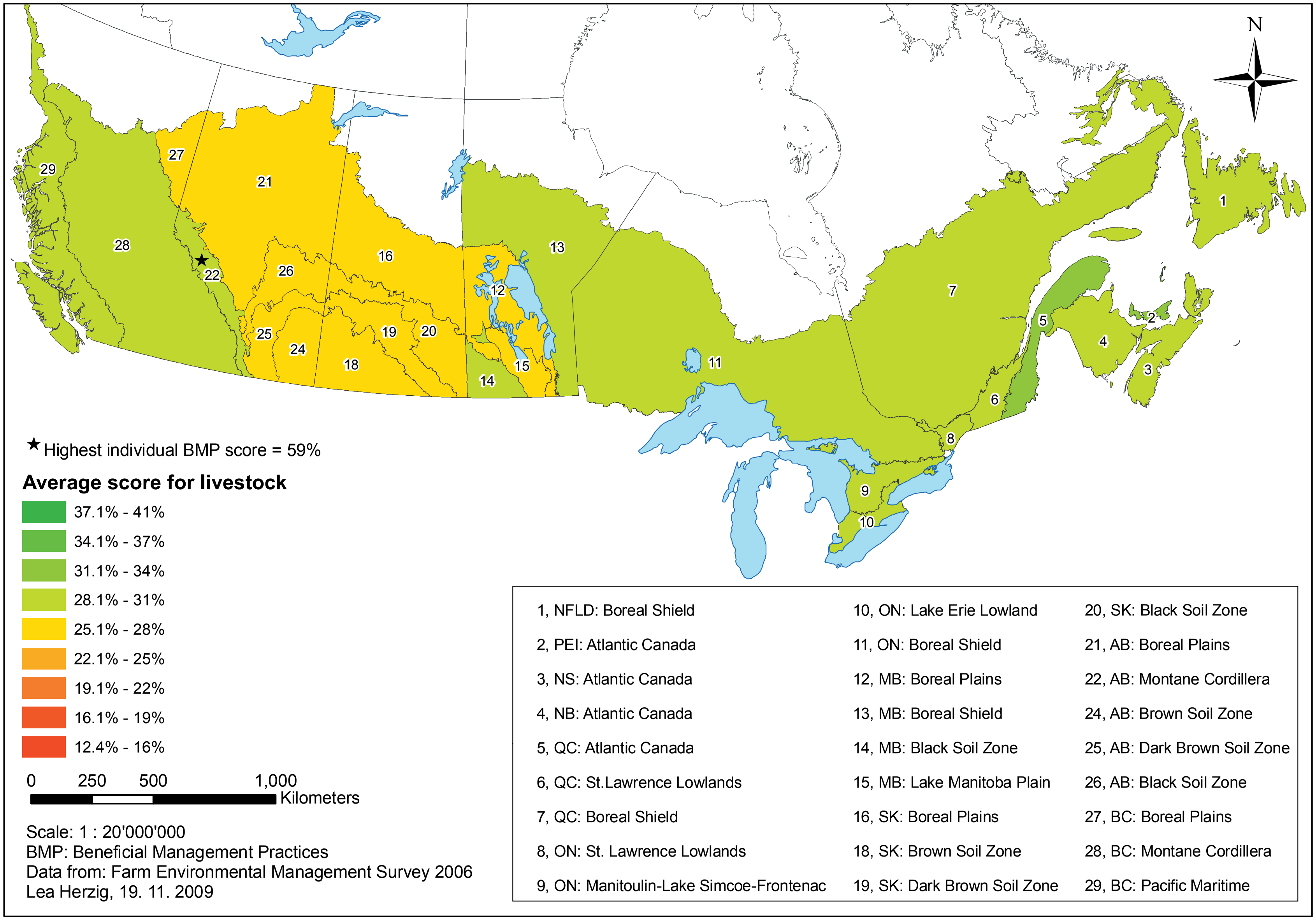


Figure 5: Risk to soil quality by agriculture

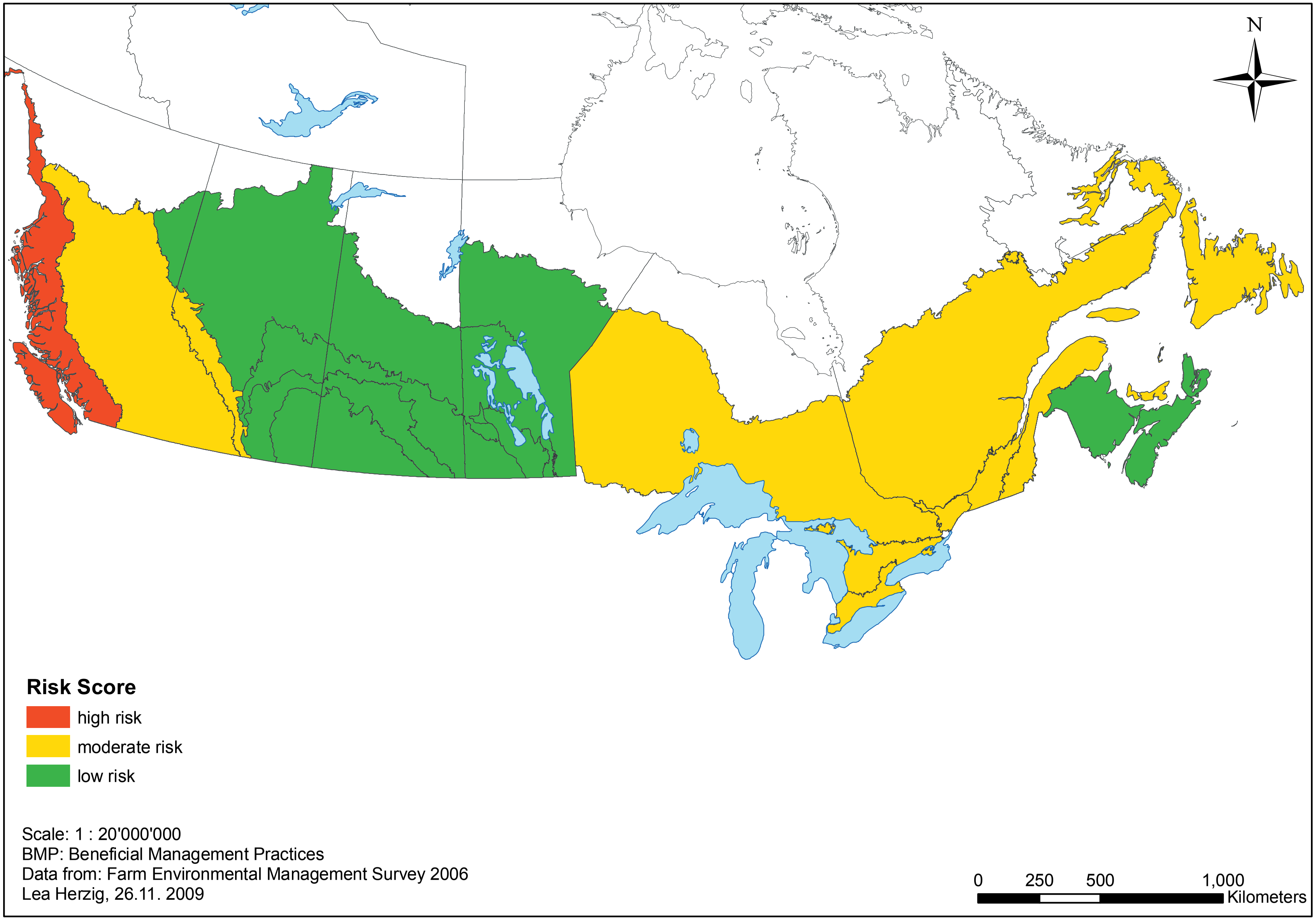


Figure 6: Adoption of soil quality BMPs by all producers

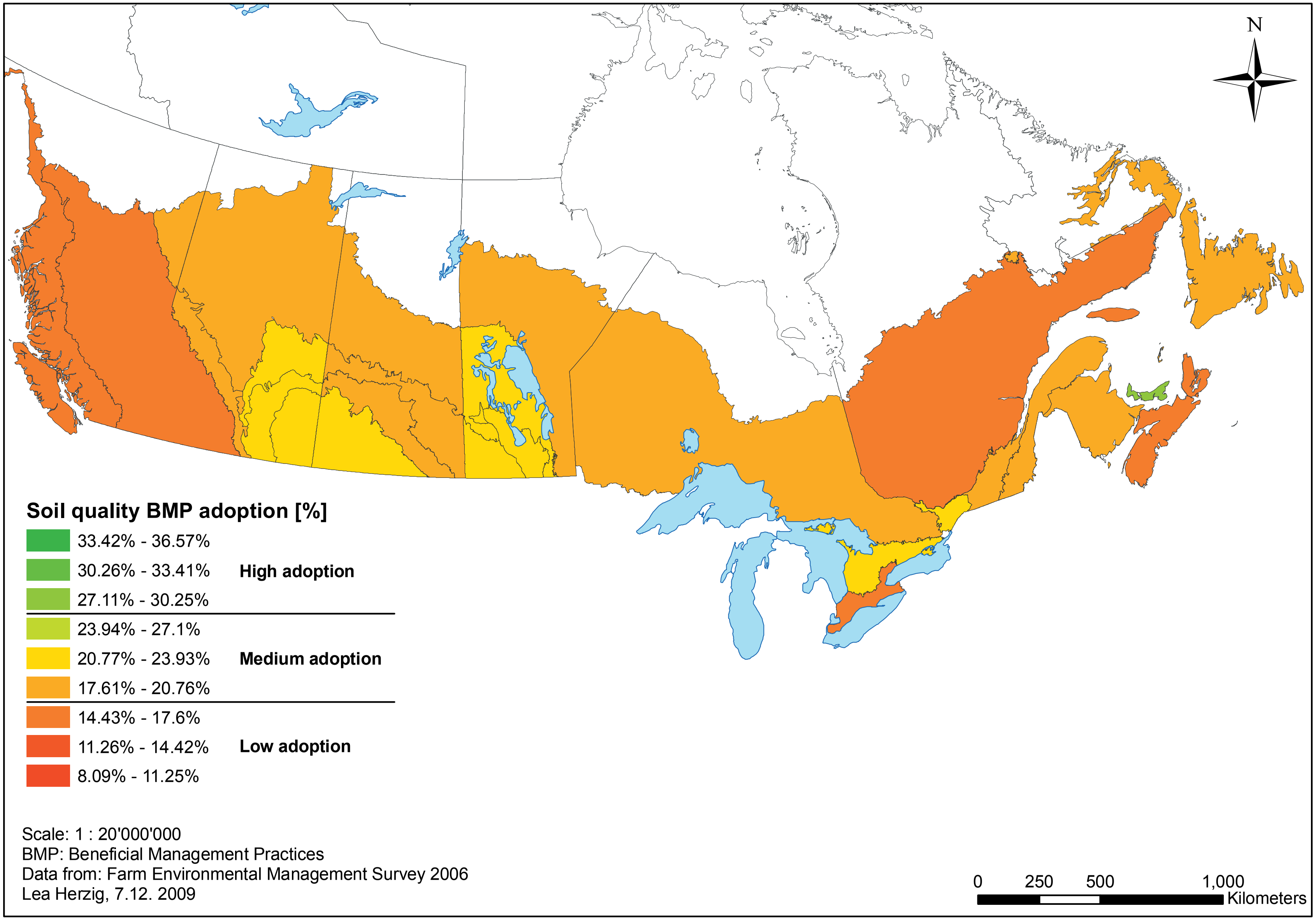


Figure 7: Adoption of soil quality BMPs by crop producers

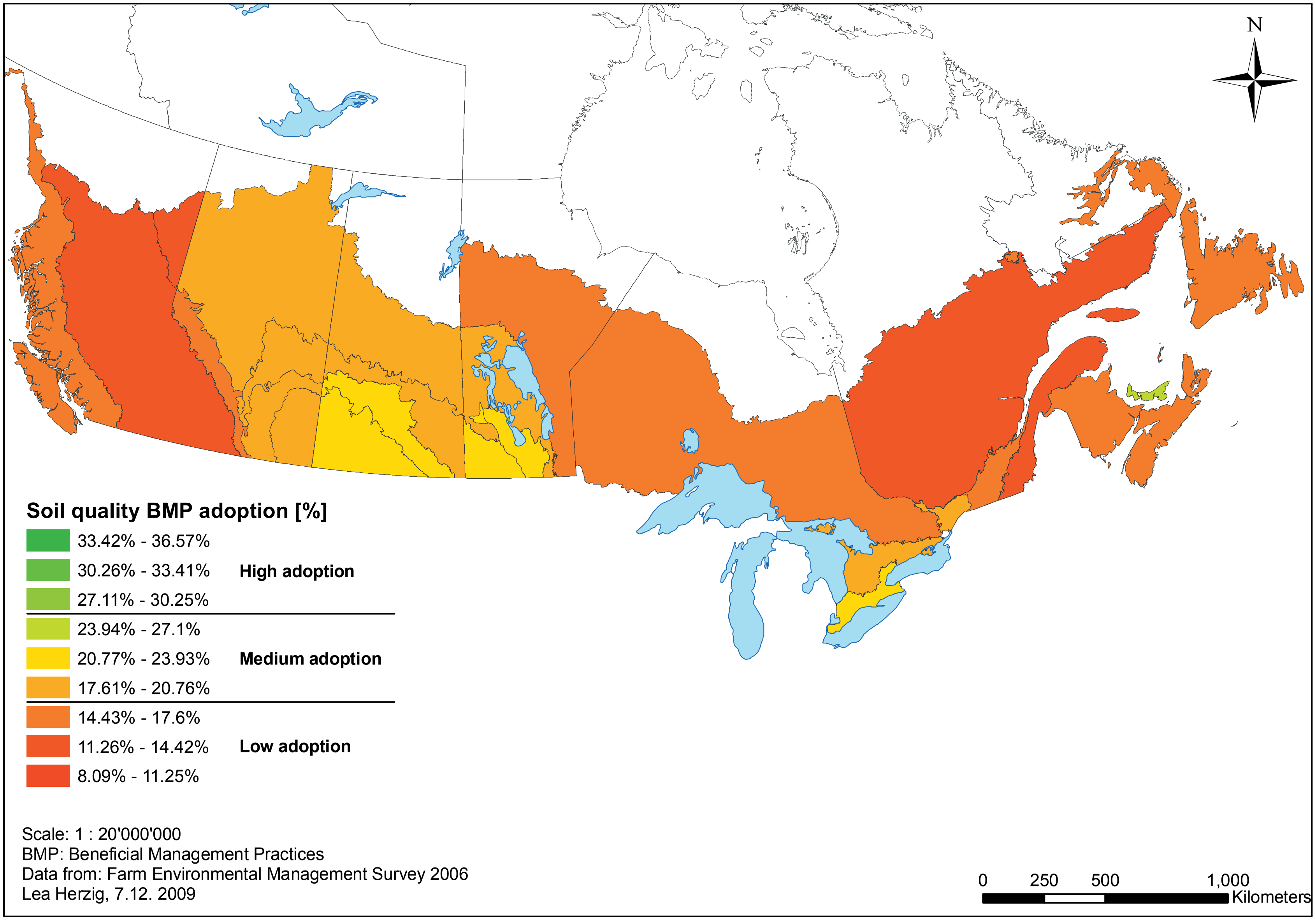


Figure 8: Adoption of soil quality BMPs by livestock producers

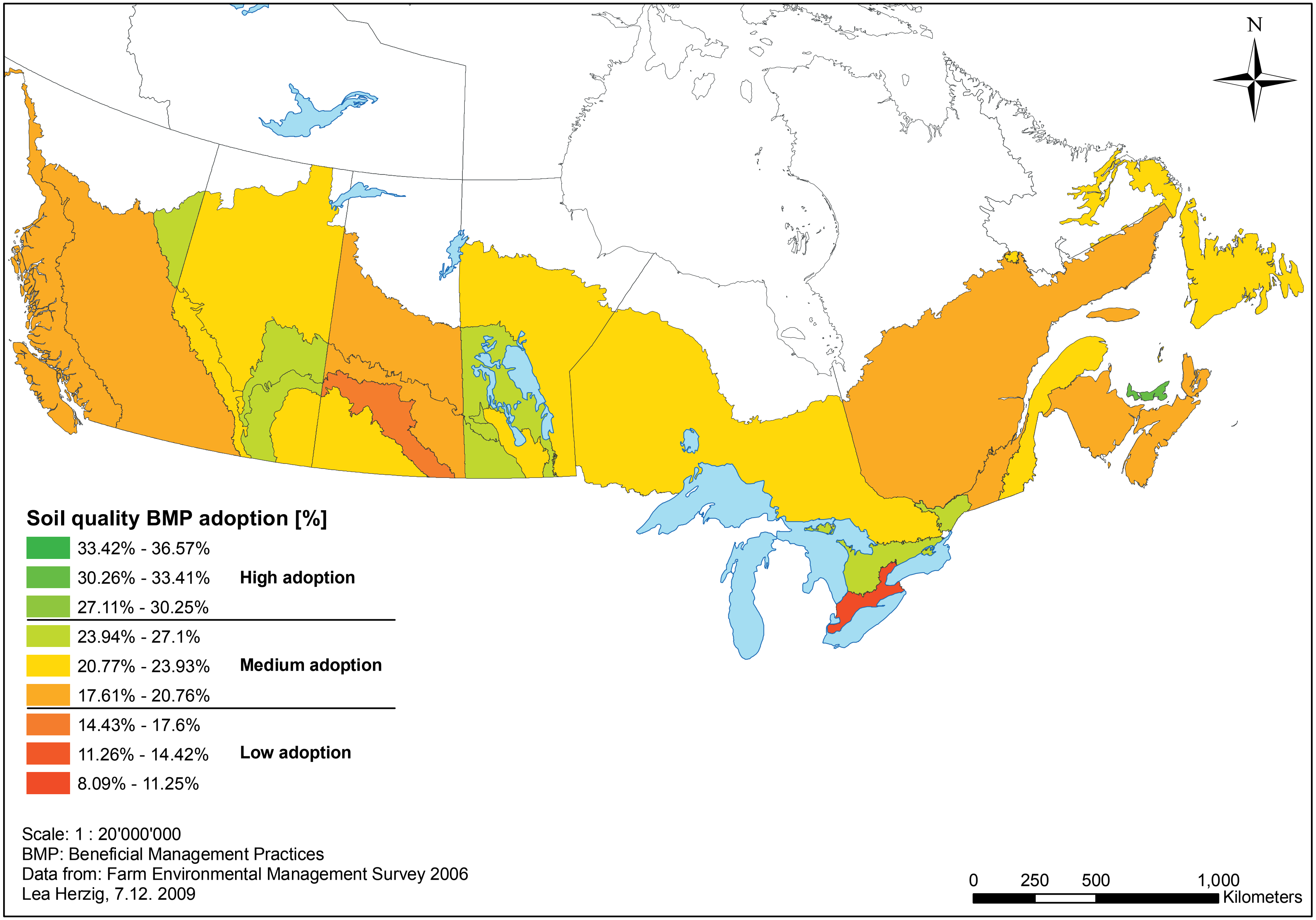


Figure 9: All producers: BMP adoption vs. risk to soil quality

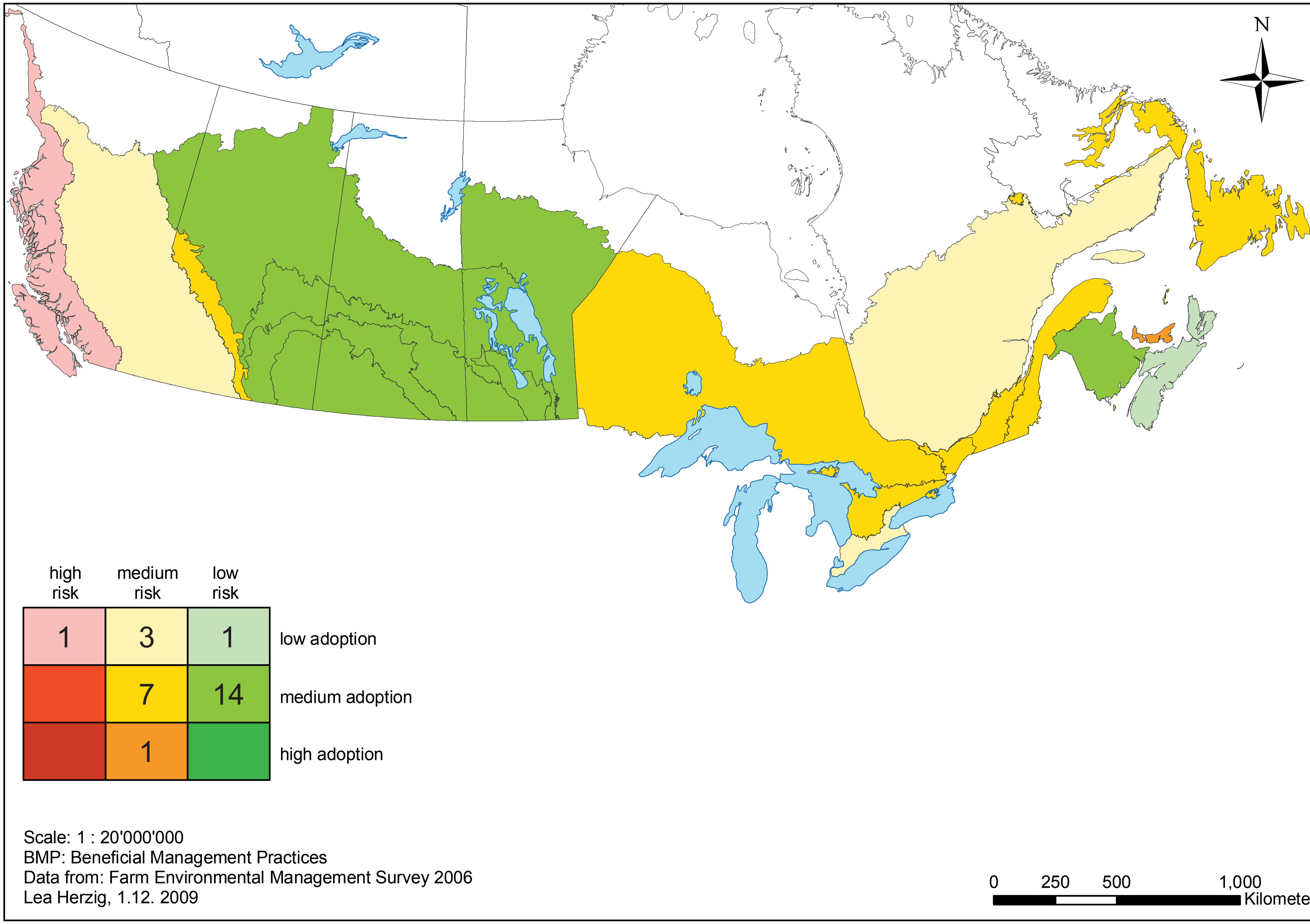


Figure 10: Crop producers: BMP adoption vs. risk to soil quality

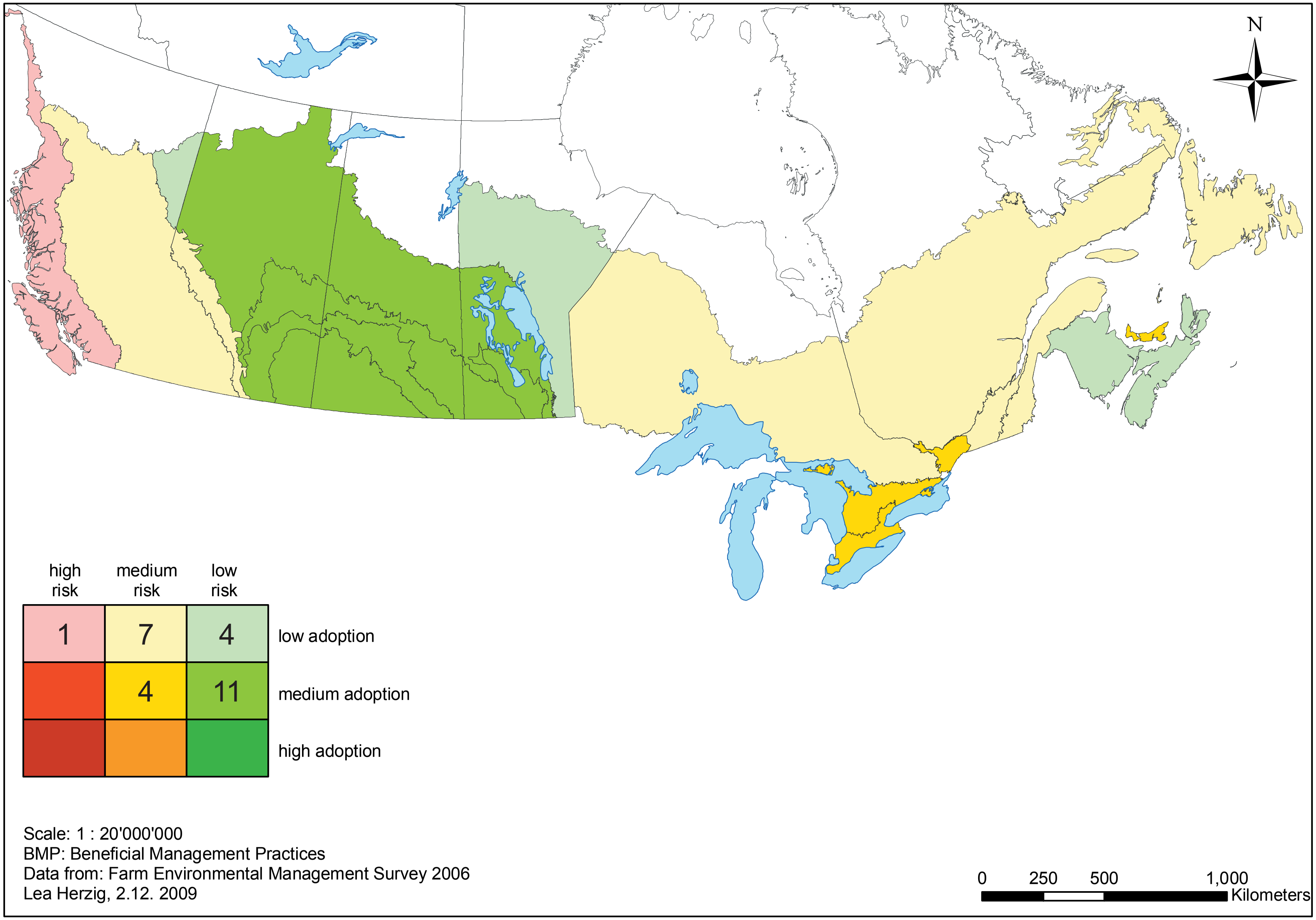


Figure 11: Livestock producers: BMP adoption vs. risk to soil quality

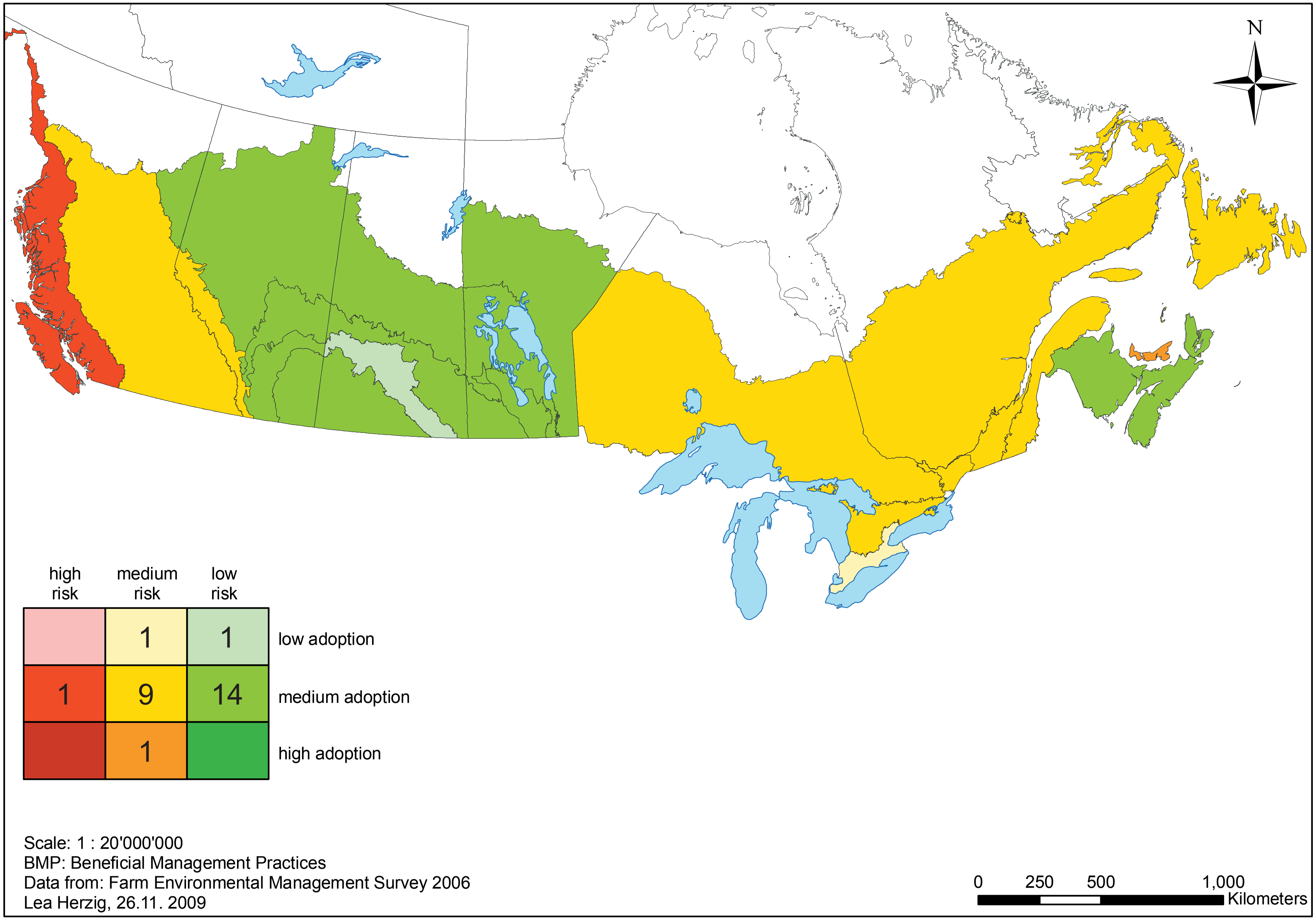


Figure 12: Risk to water quality by agriculture

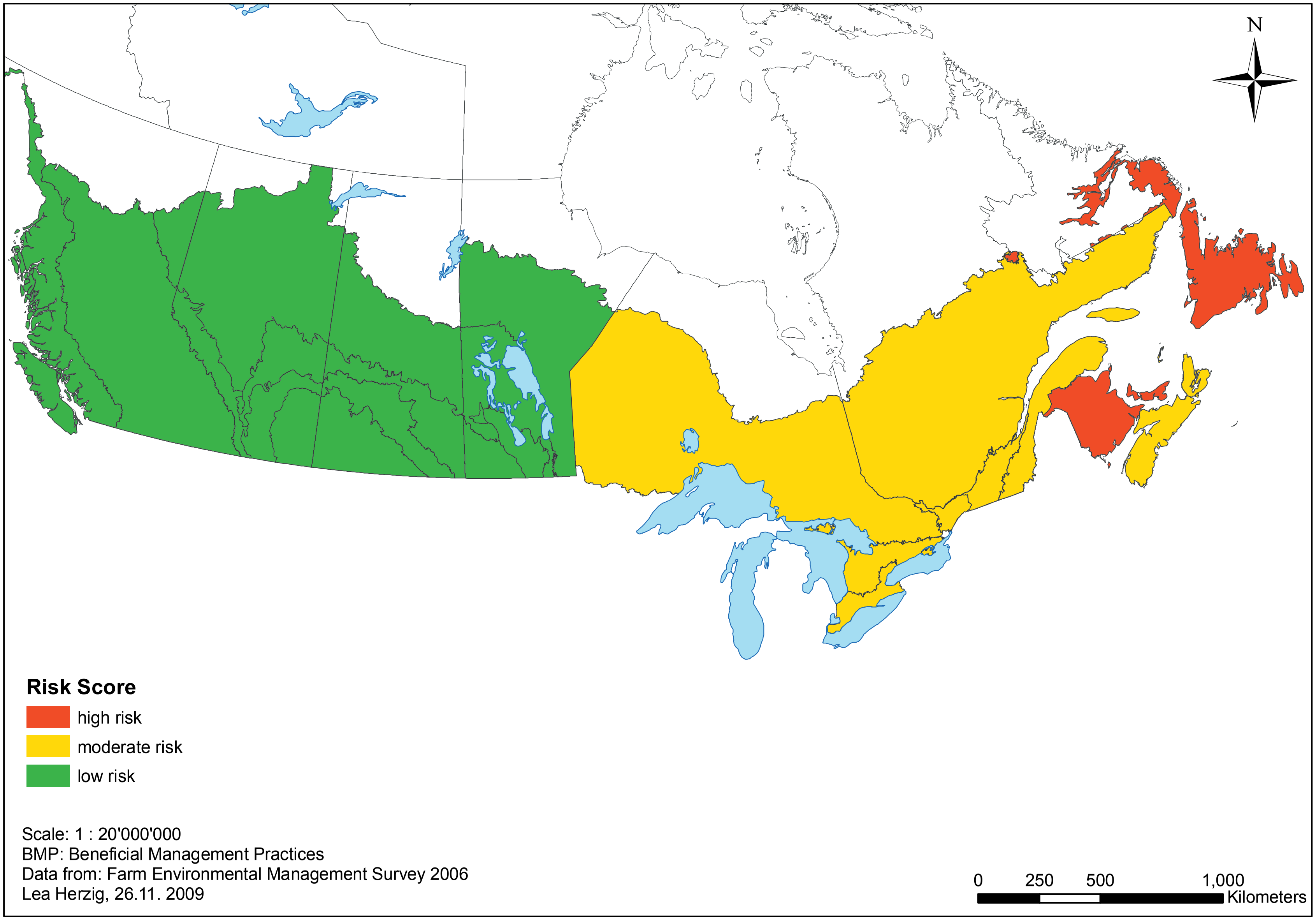


Figure 13: Adoption of water quality BMPs by all producers

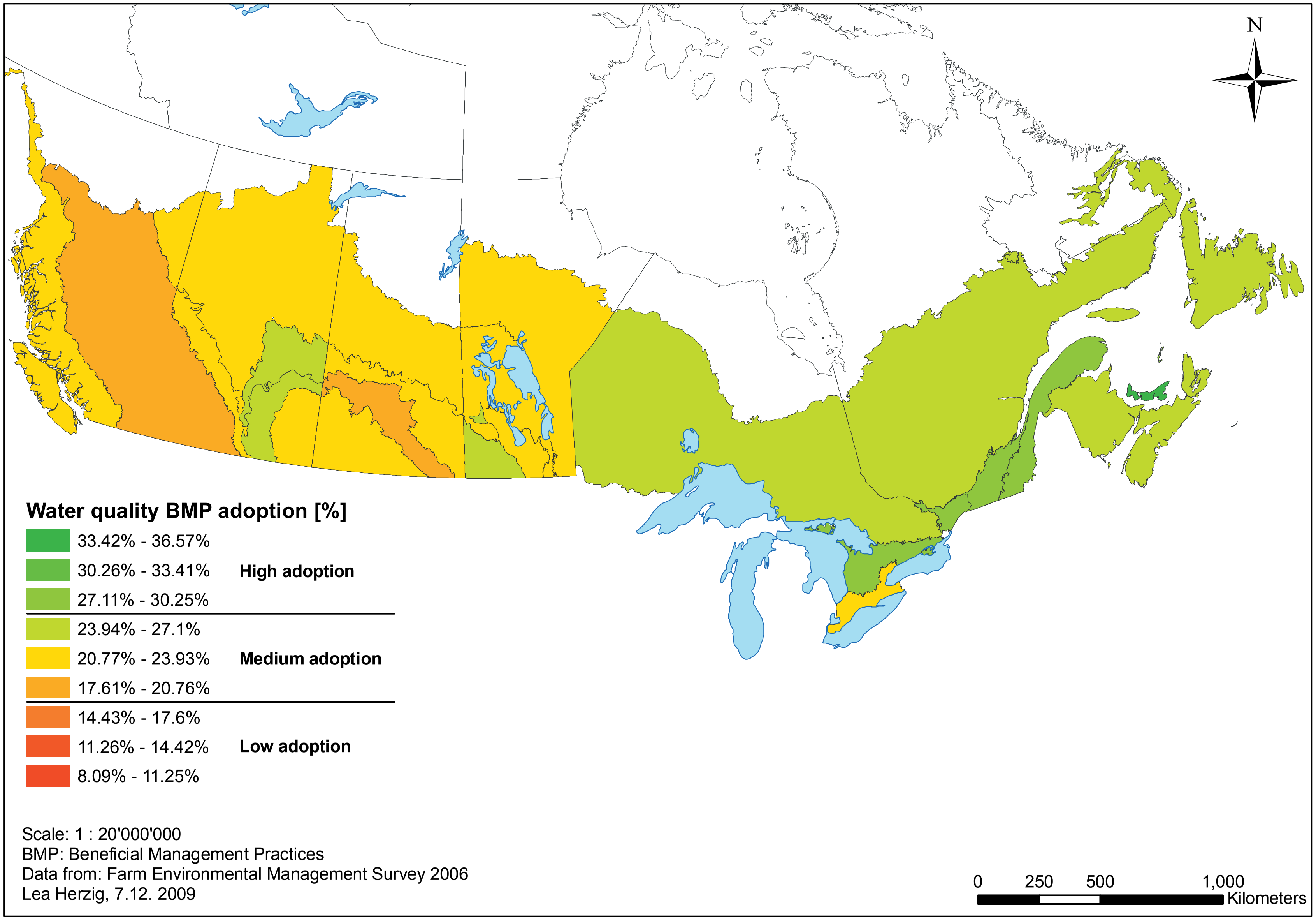


Figure 14: Adoption of water quality BMPs by crop producers

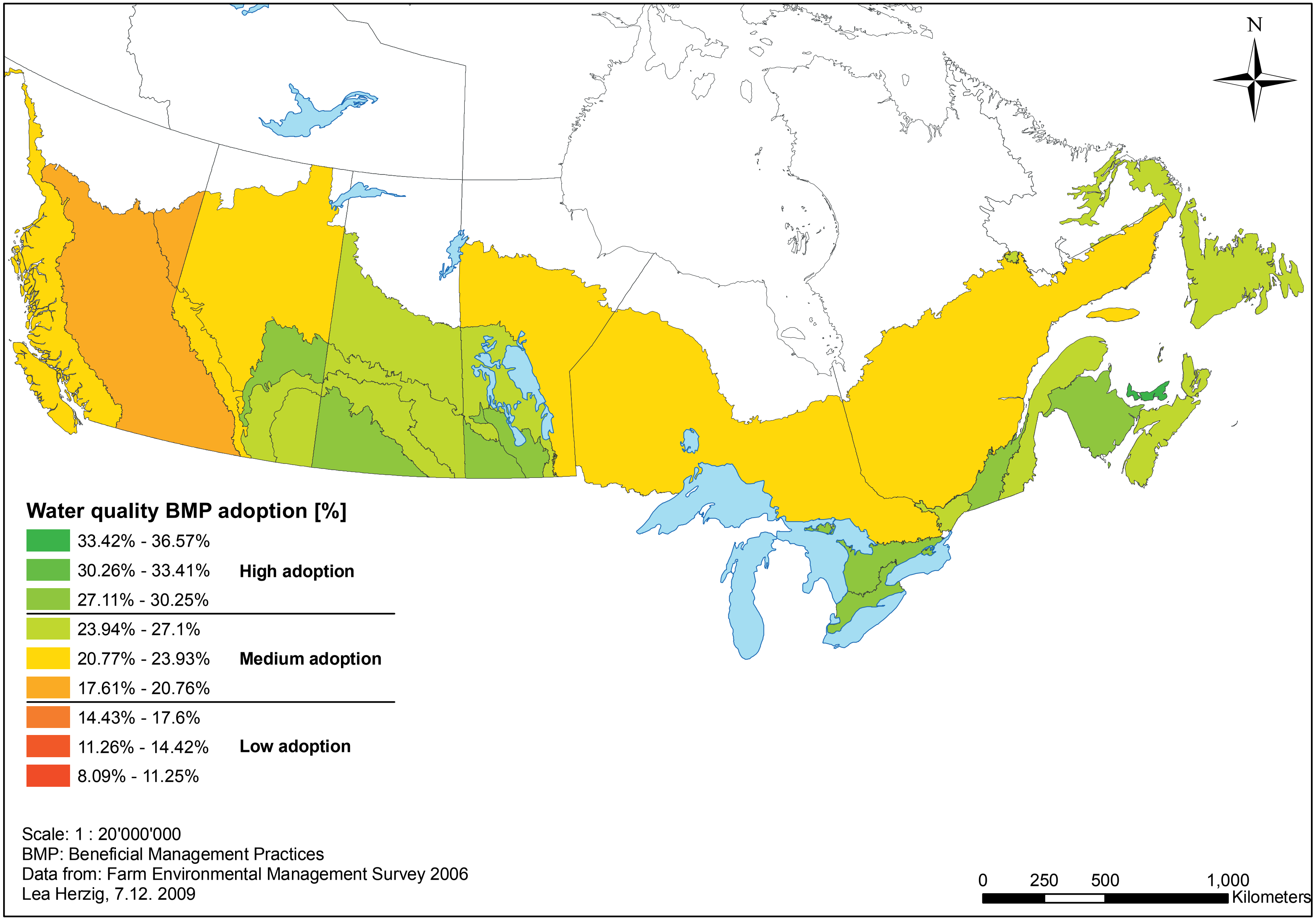


Figure 15: Adoption of water quality BMPs by livestock producers

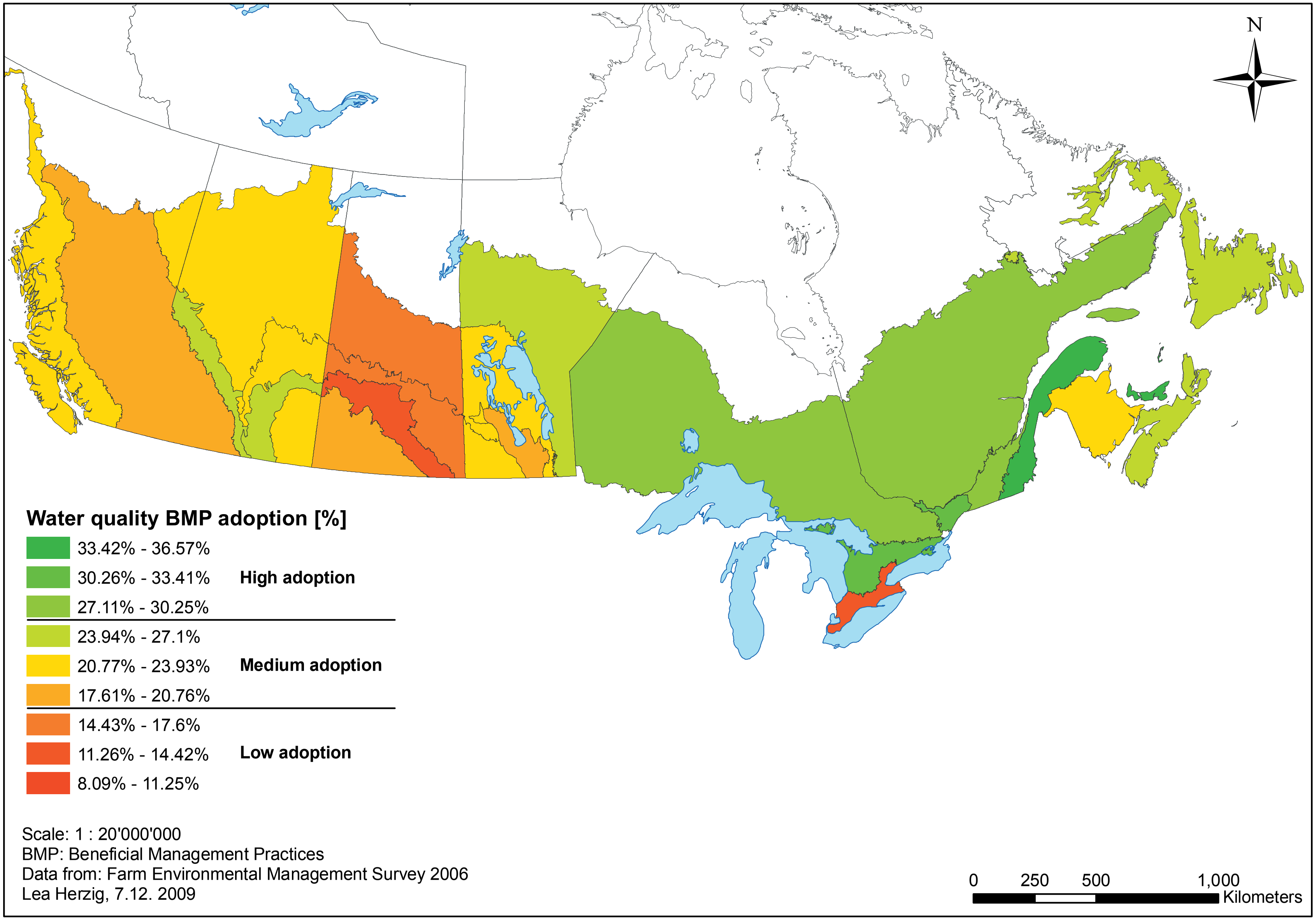


Figure 16: All producers: BMP adoption vs. risk to water quality

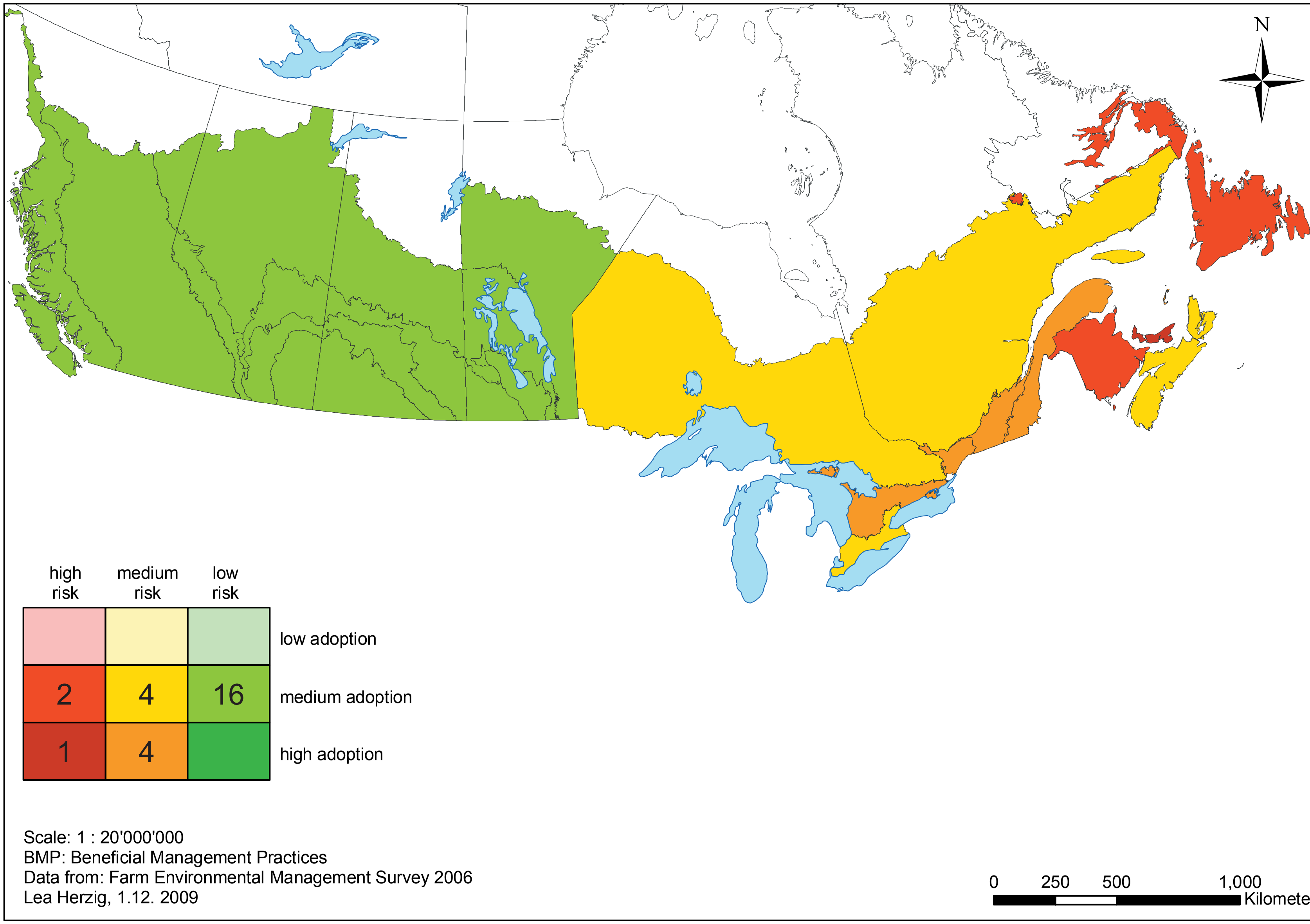


Figure 17: Crop producers: BMP adoption vs. risk to water quality

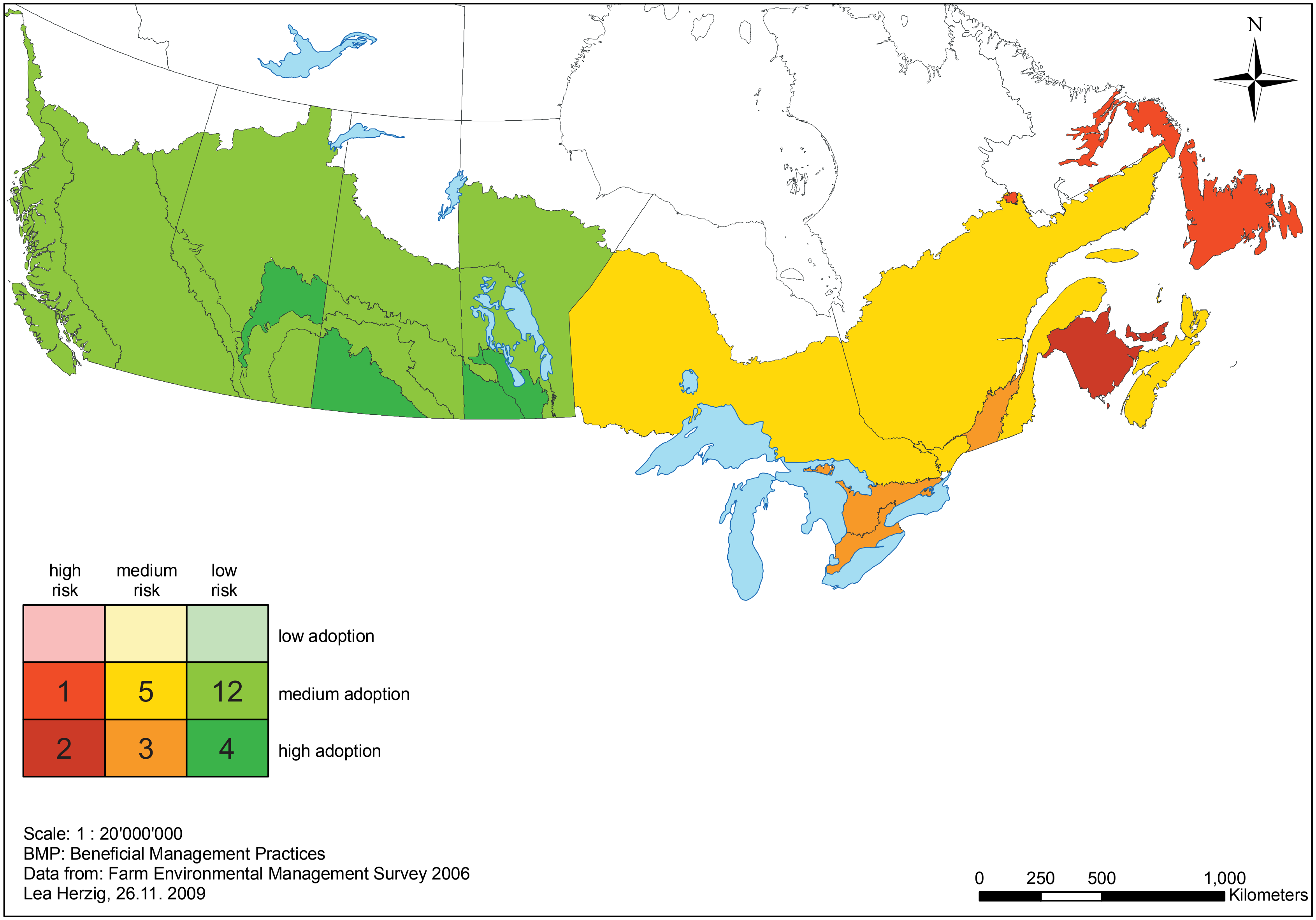


Figure 18: Livestock producers: BMP adoption vs. risk to water quality

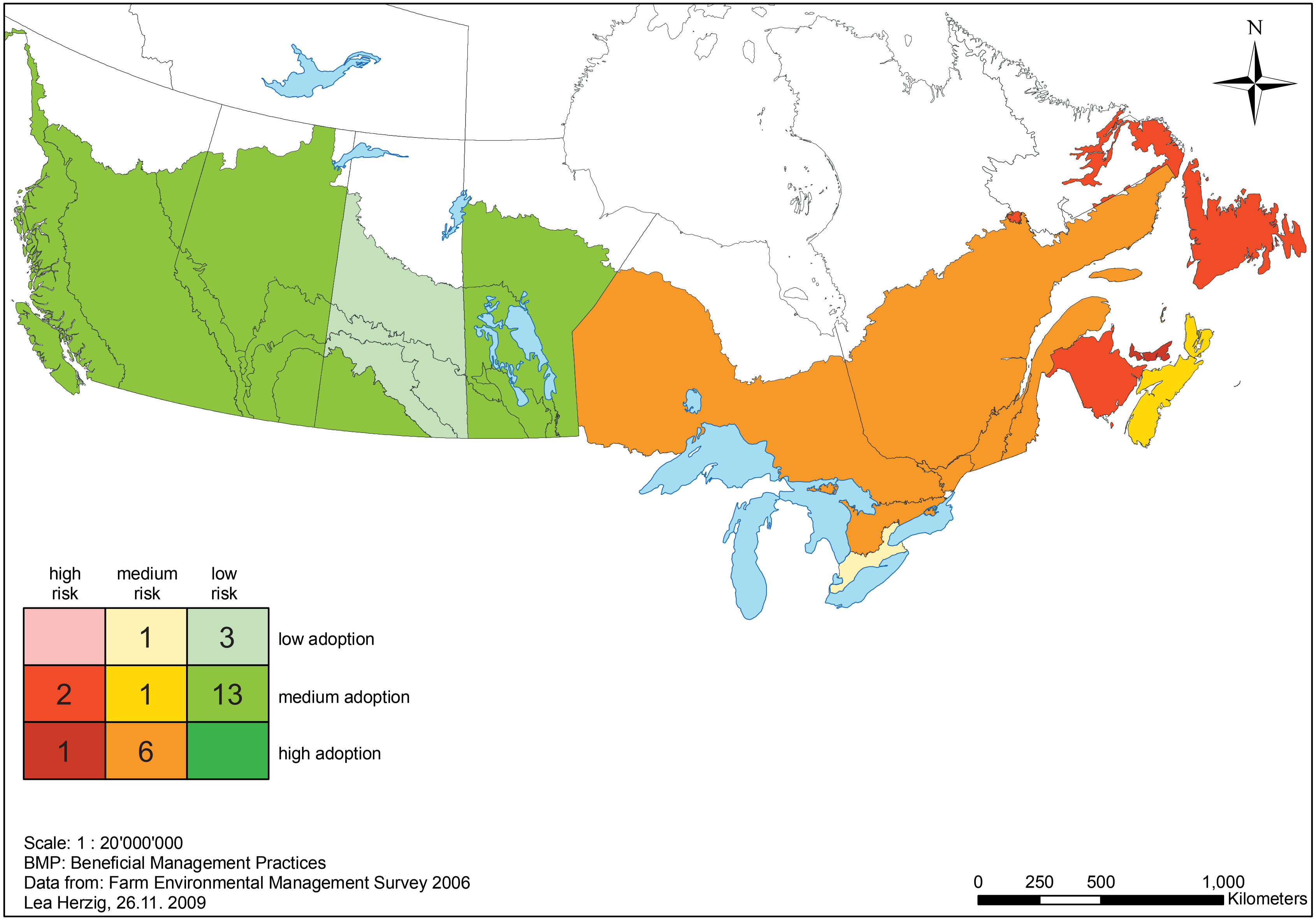


Figure 19: Risk to air quality by agriculture

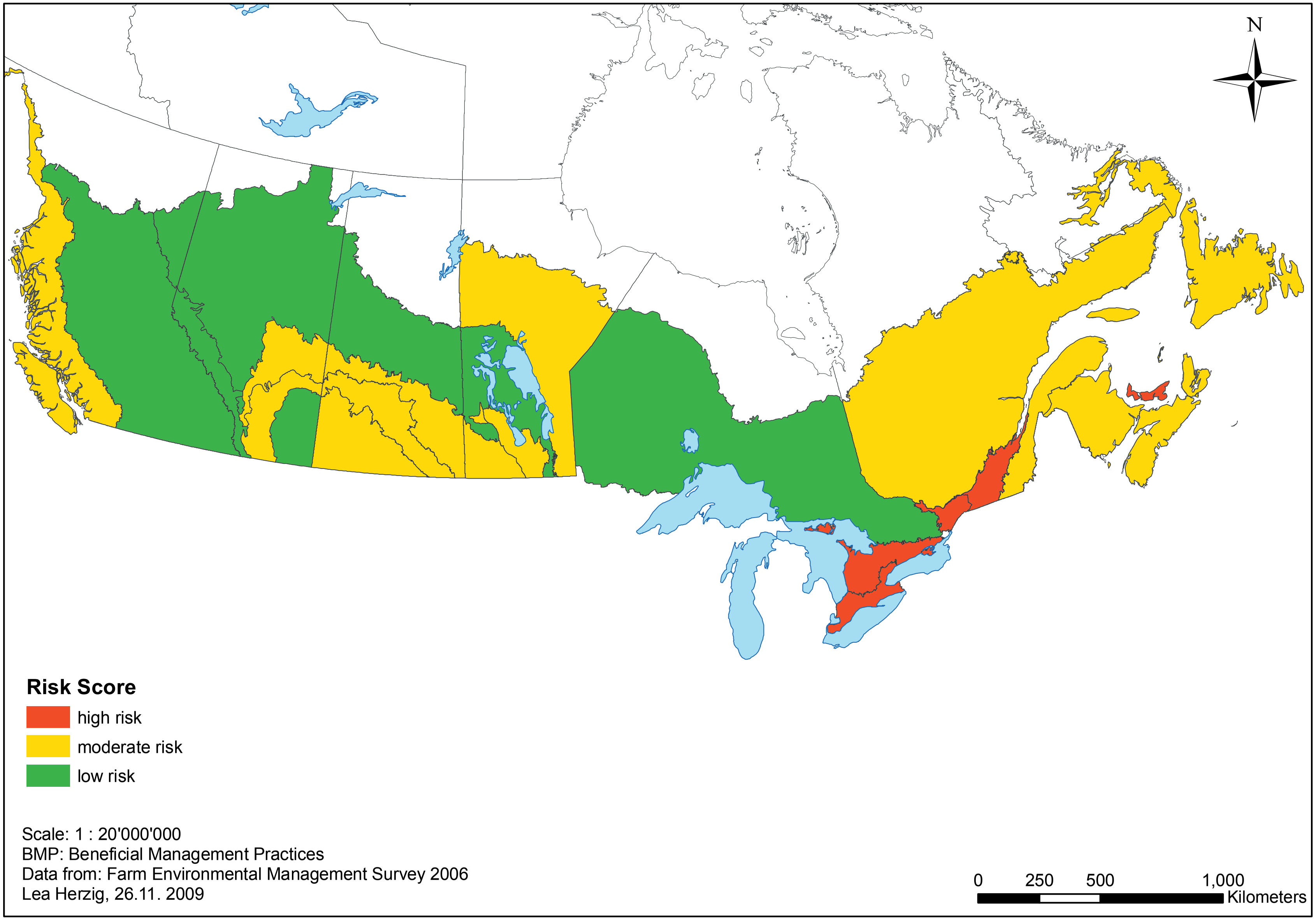


Figure 20: Adoption of air quality BMPs by all producers

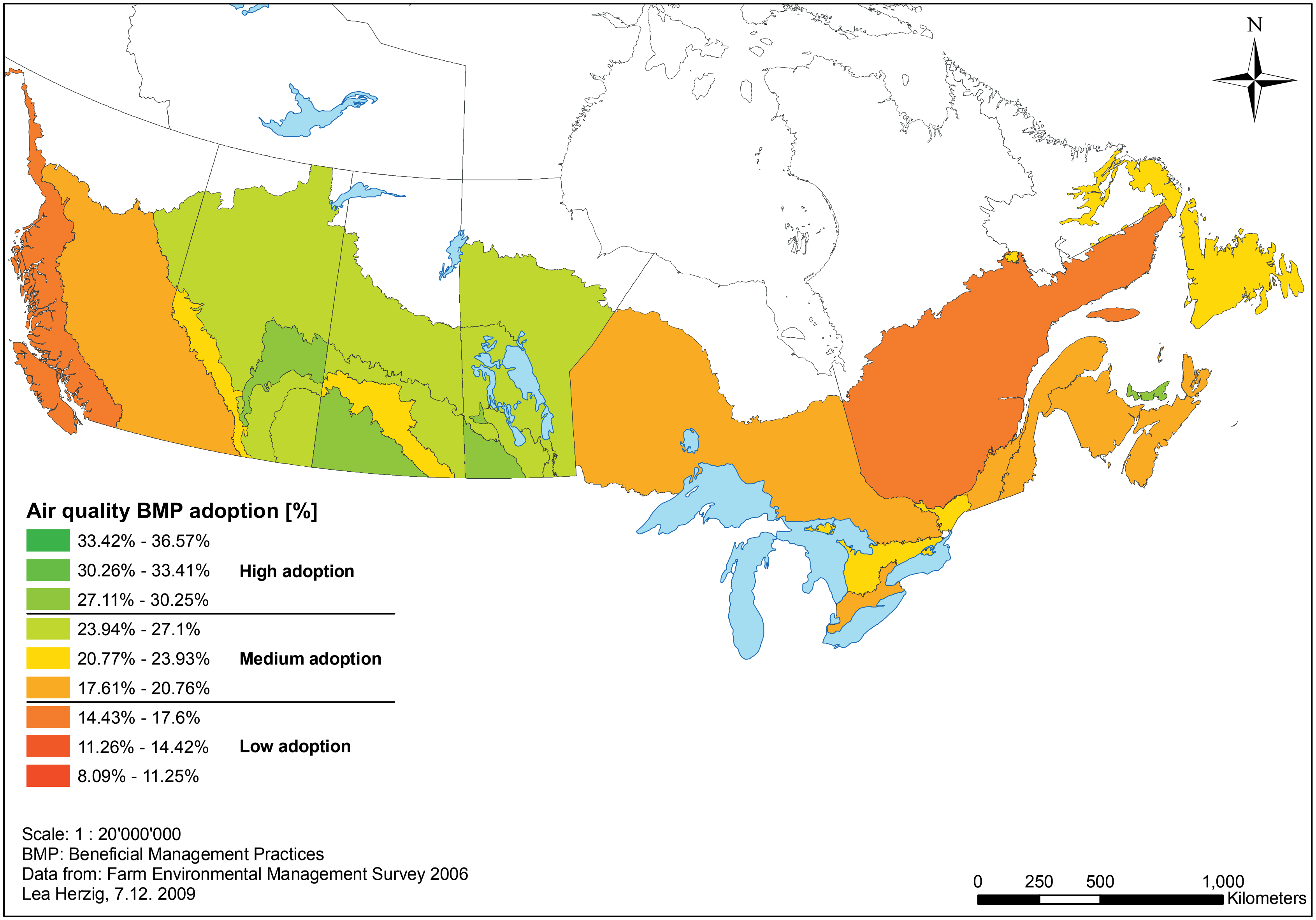


Figure 21: Adoption of air quality BMPs by crop producers

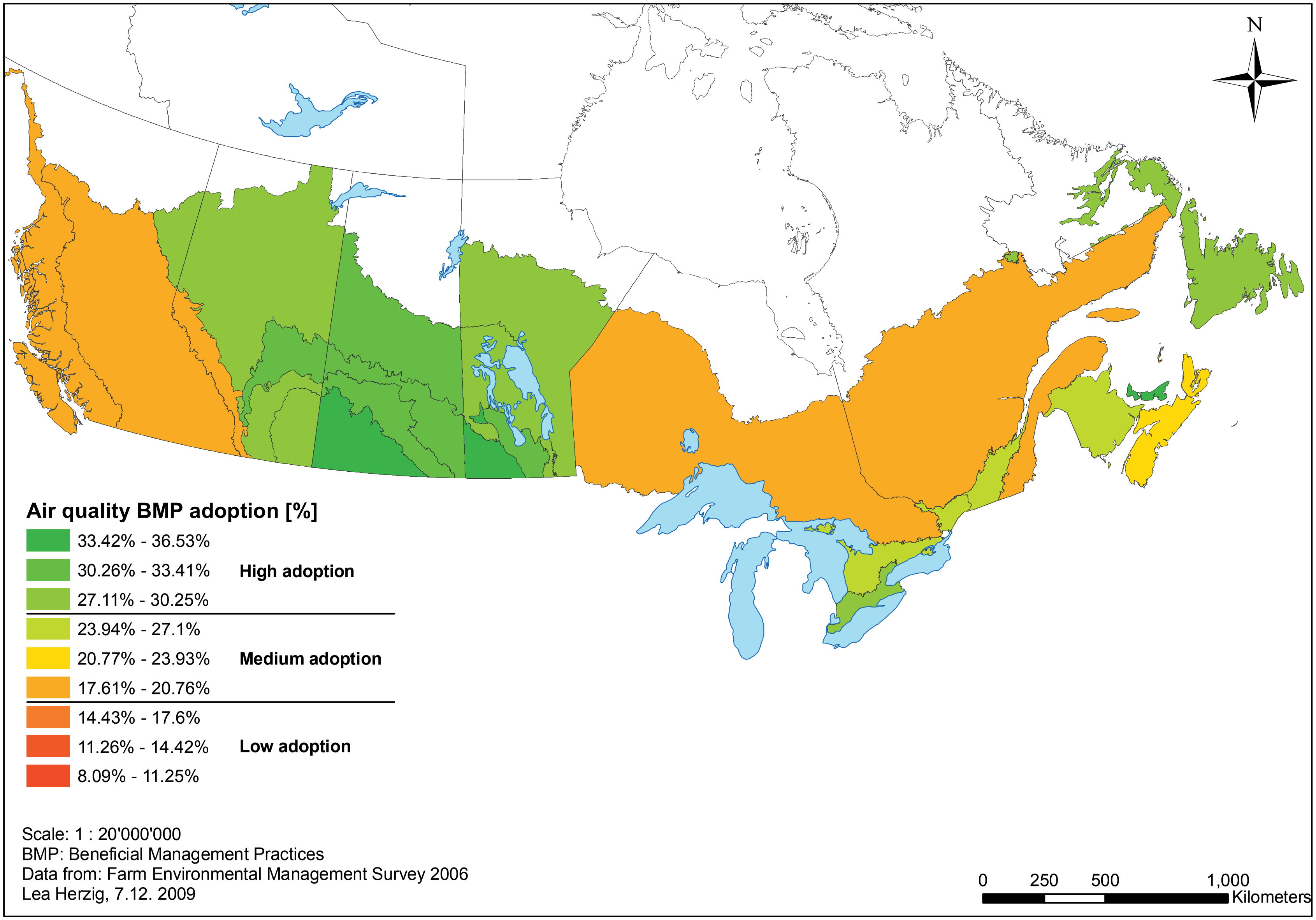


Figure 22: Adoption of air quality BMPs by livestock producers

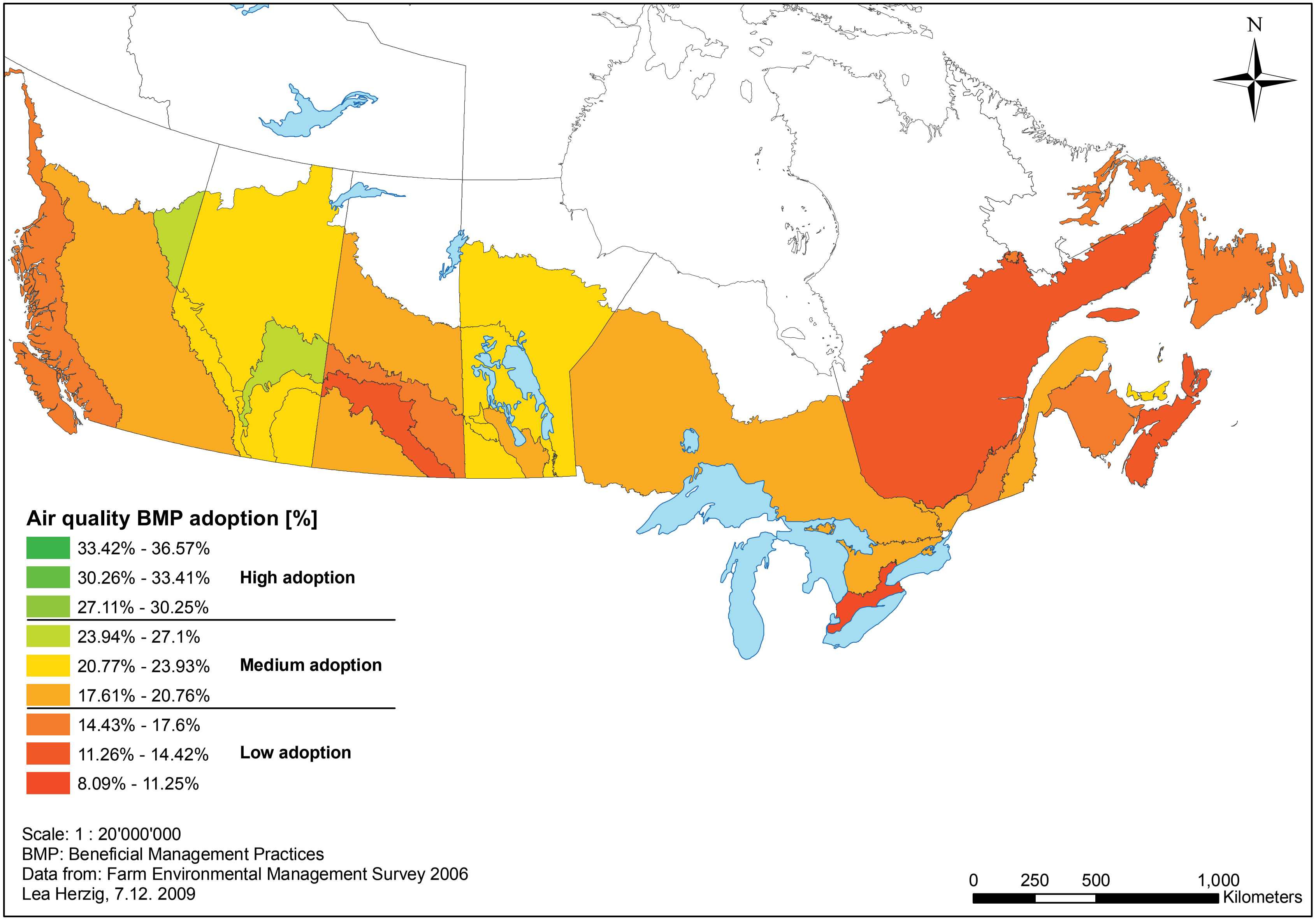


Figure 23: All producers: BMP adoption vs. risk to air quality

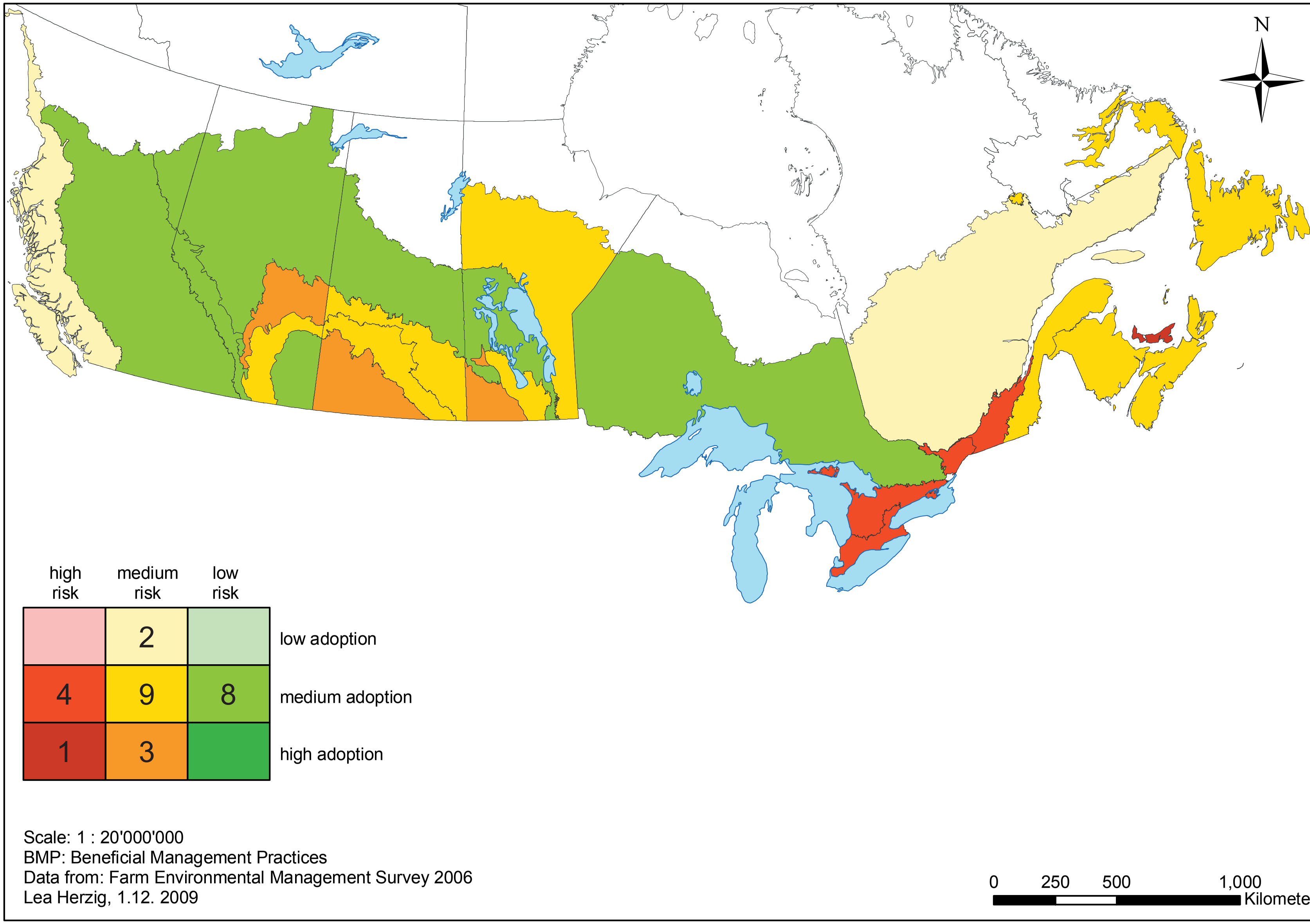


Figure 24: Crop producers: BMP adoption vs. risk to air quality

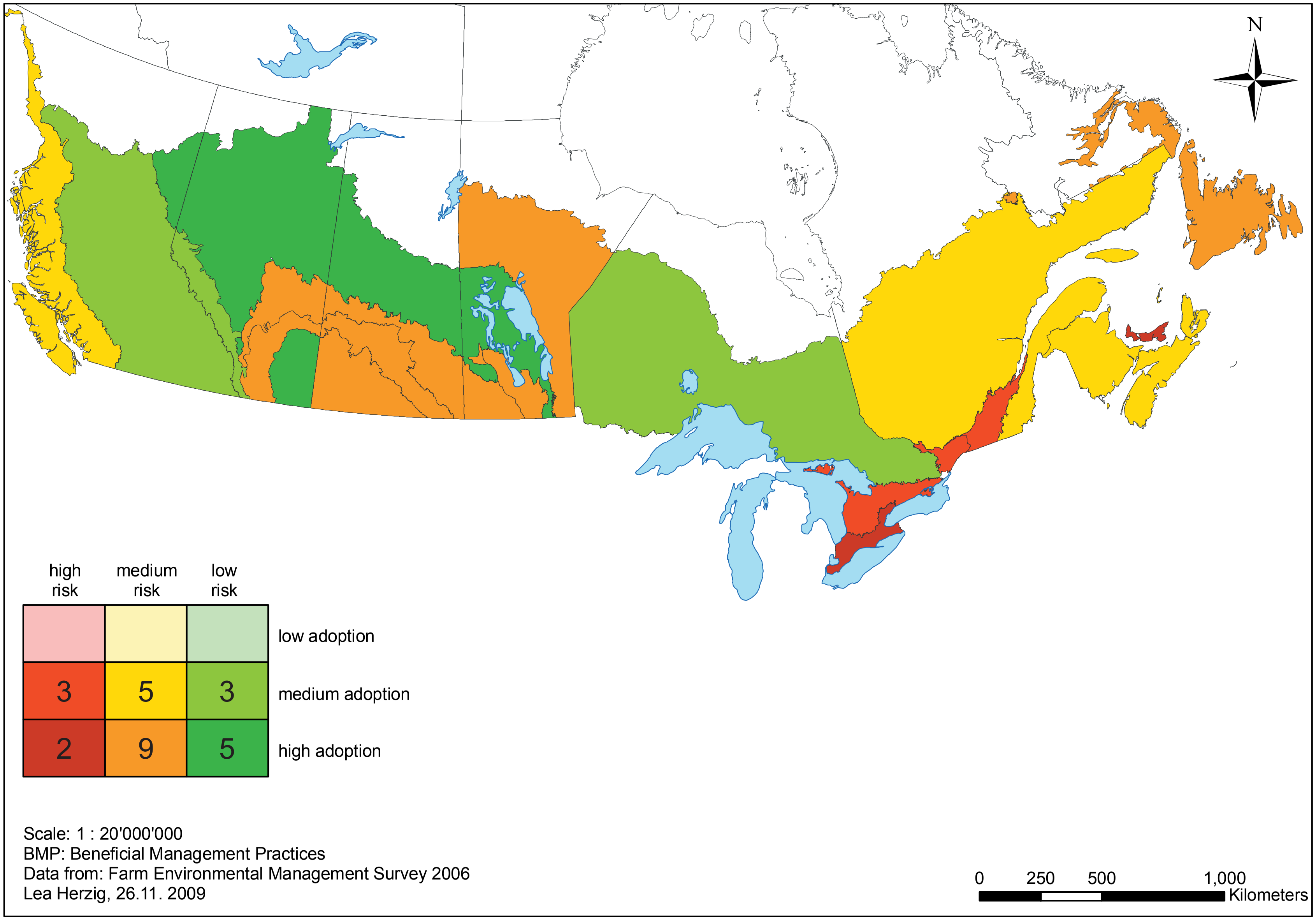


Figure 25: Livestock producers: BMP adoption vs. risk to air quality

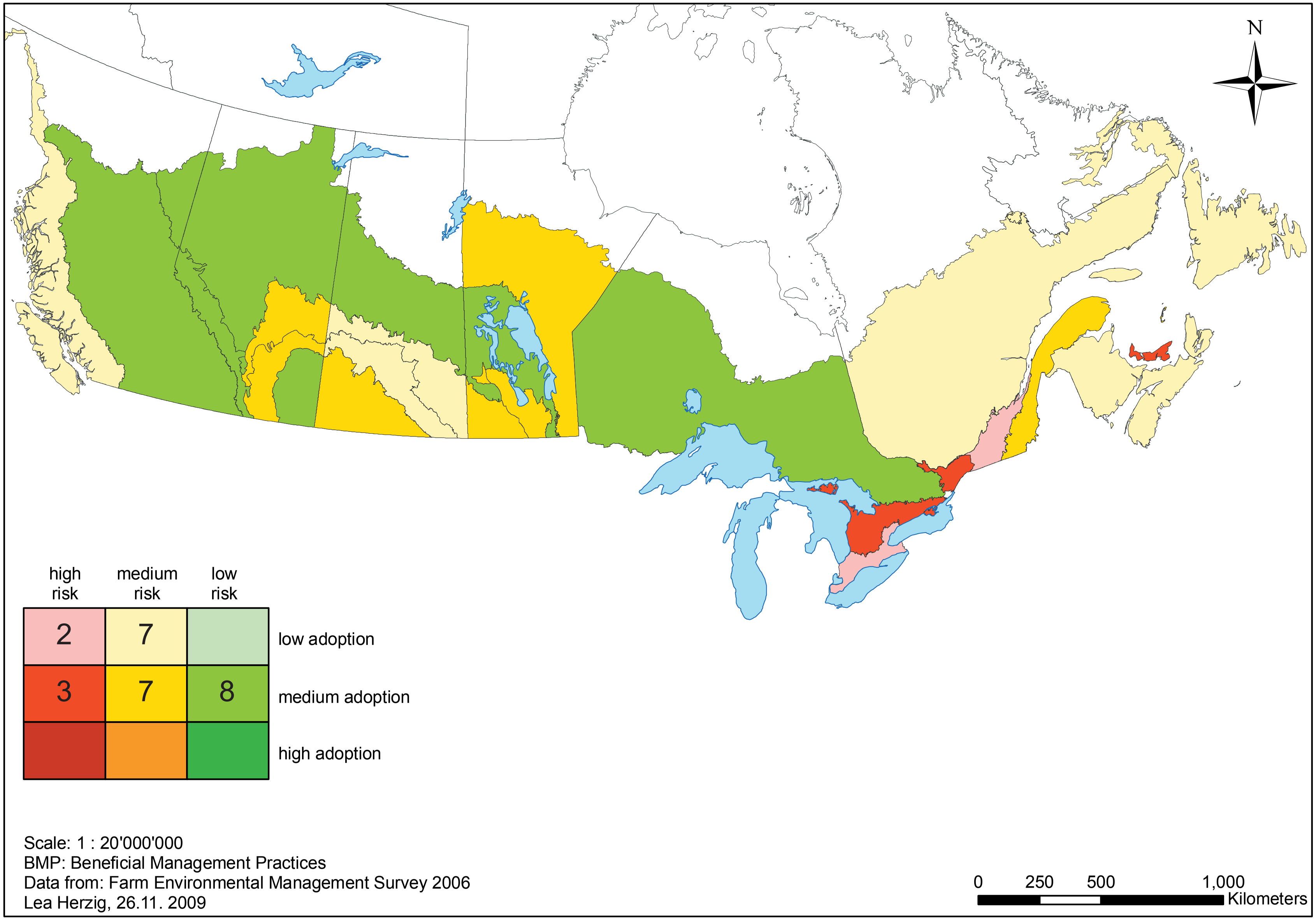


Figure 26: Risk to biodiversity by agriculture

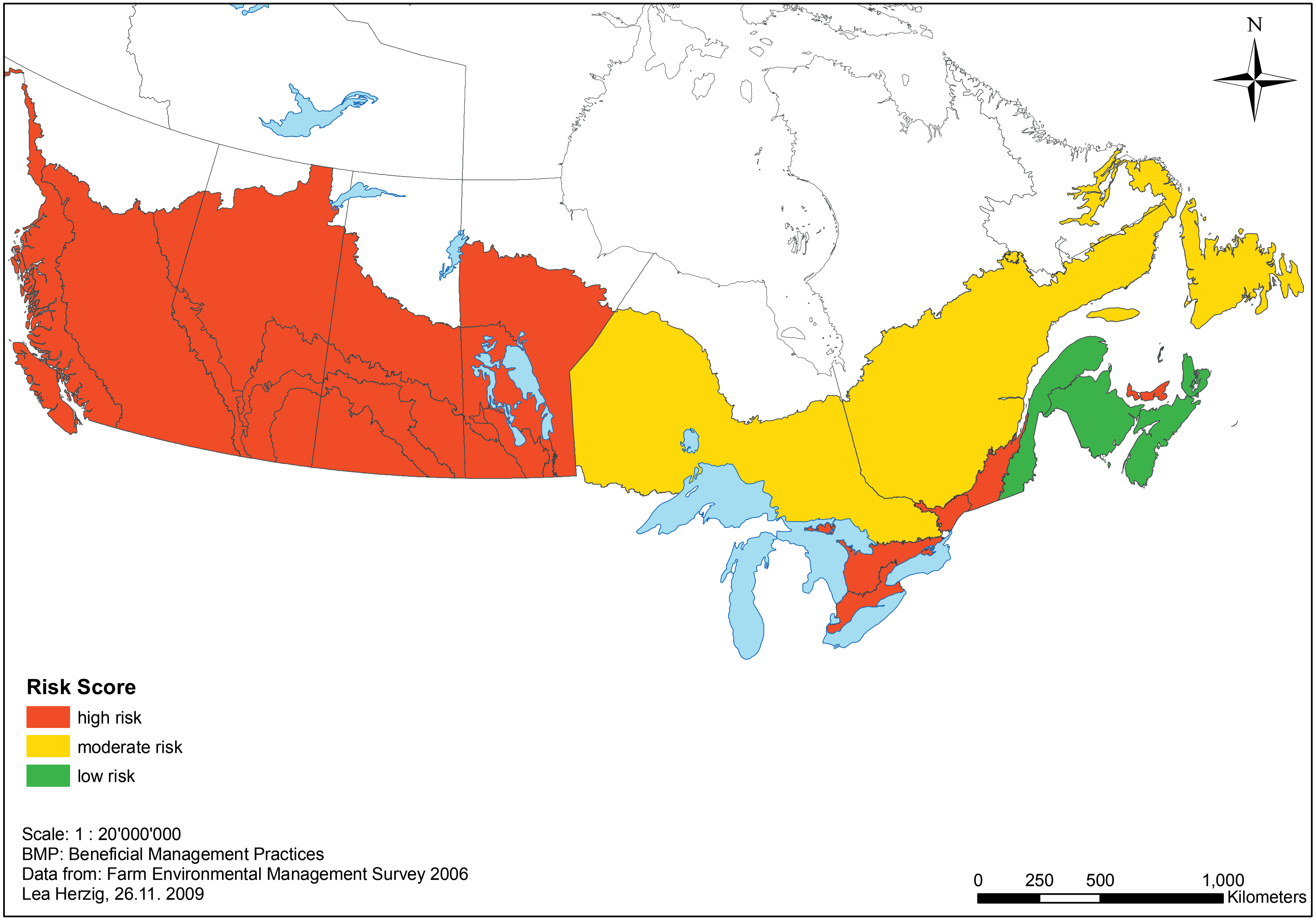


Figure 27: Adoption of biodiversity BMPs by all producers

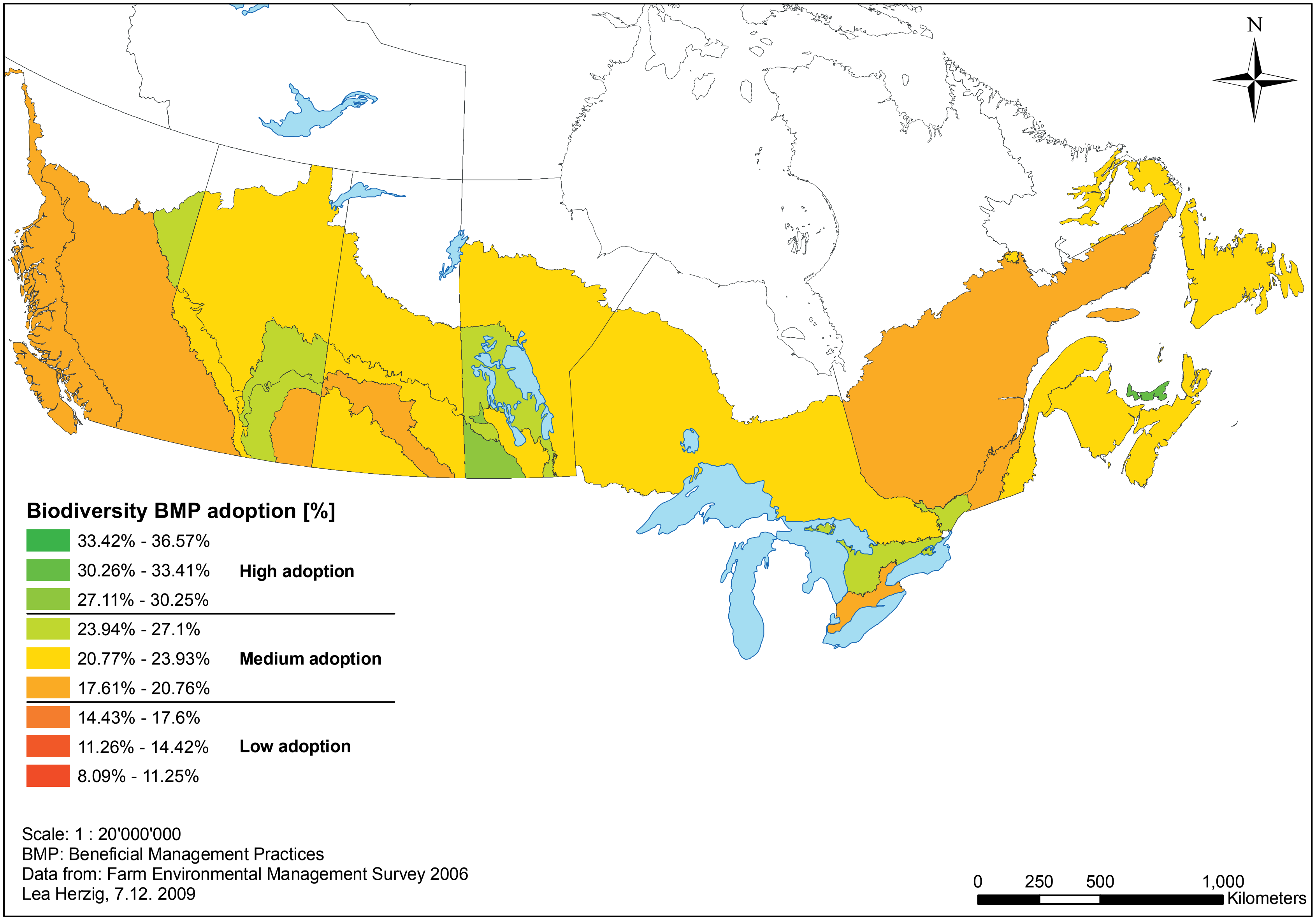


Figure 28: Adoption of biodiversity BMPs by crop producers

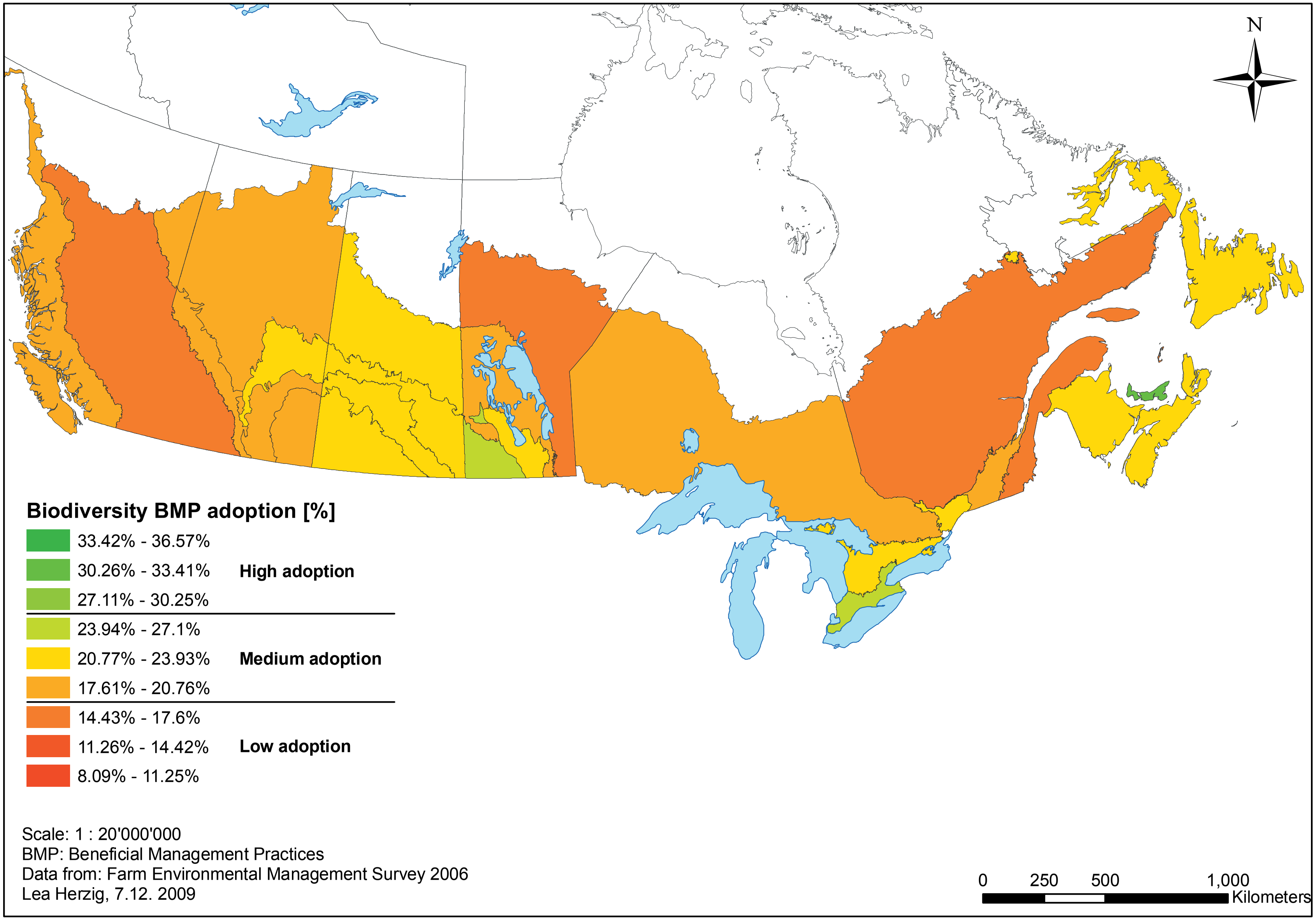


Figure 29: Adoption of biodiversity BMPs by livestock producers

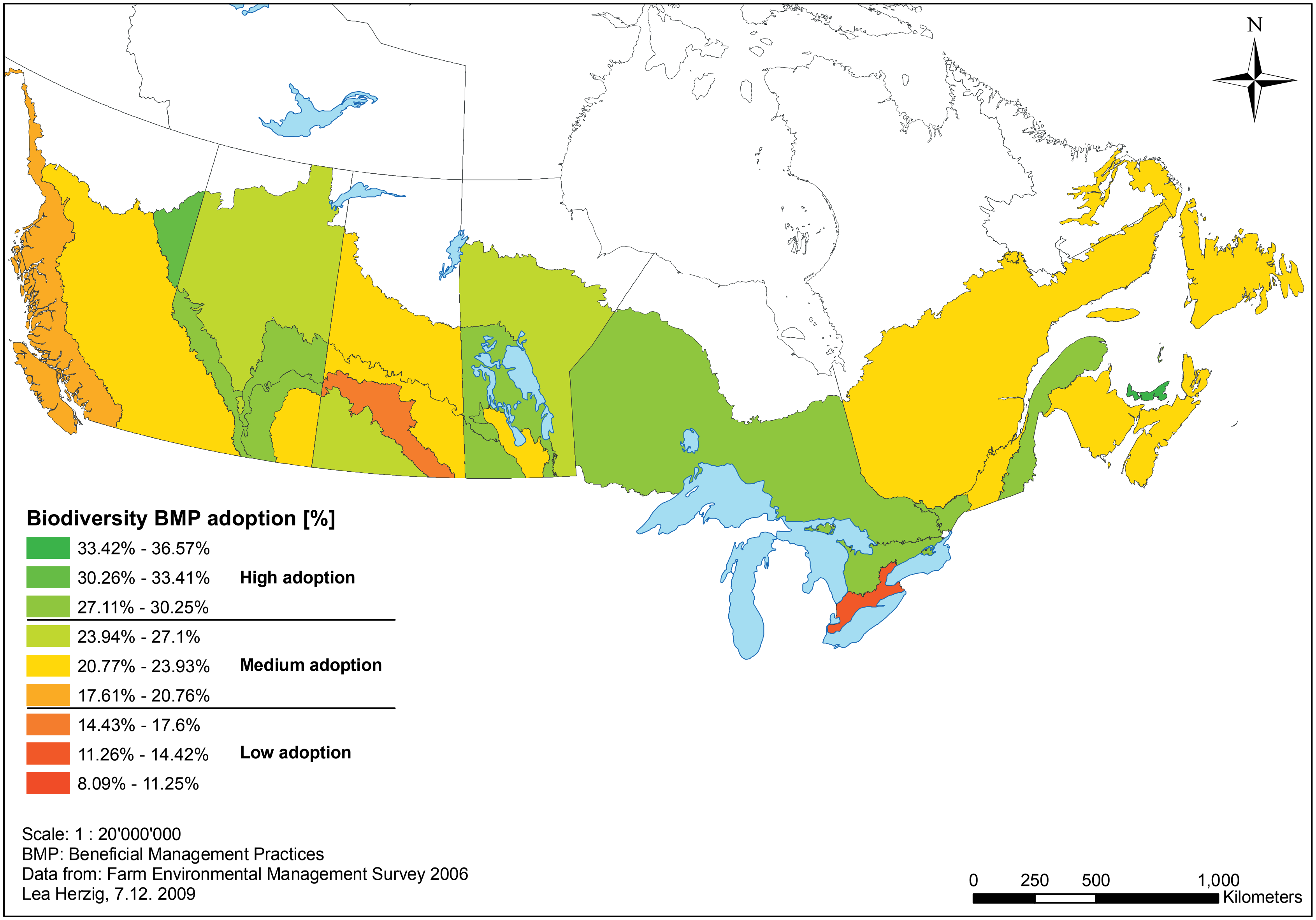


Figure 30: All producers: BMP adoption vs. risk to biodiversity

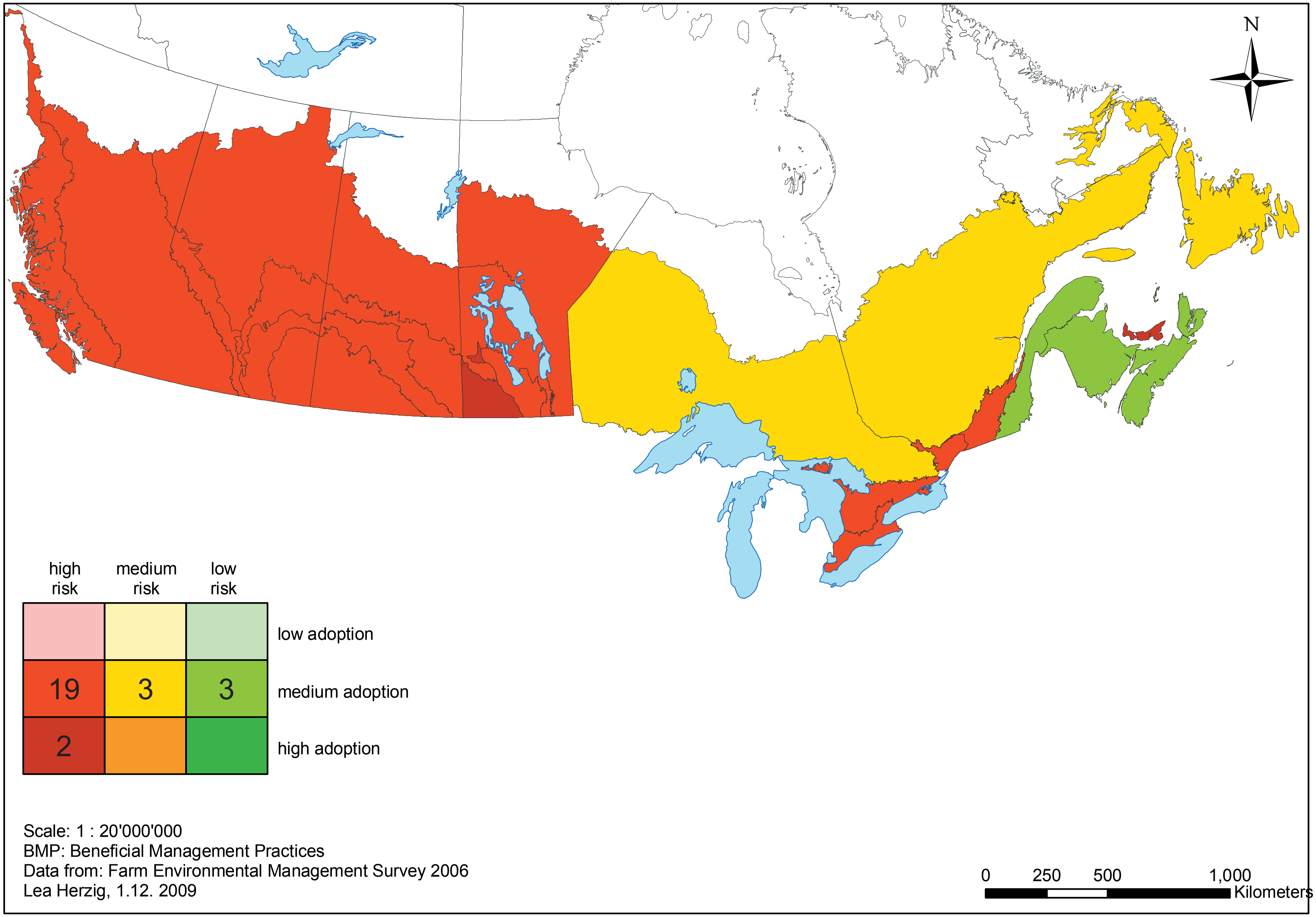
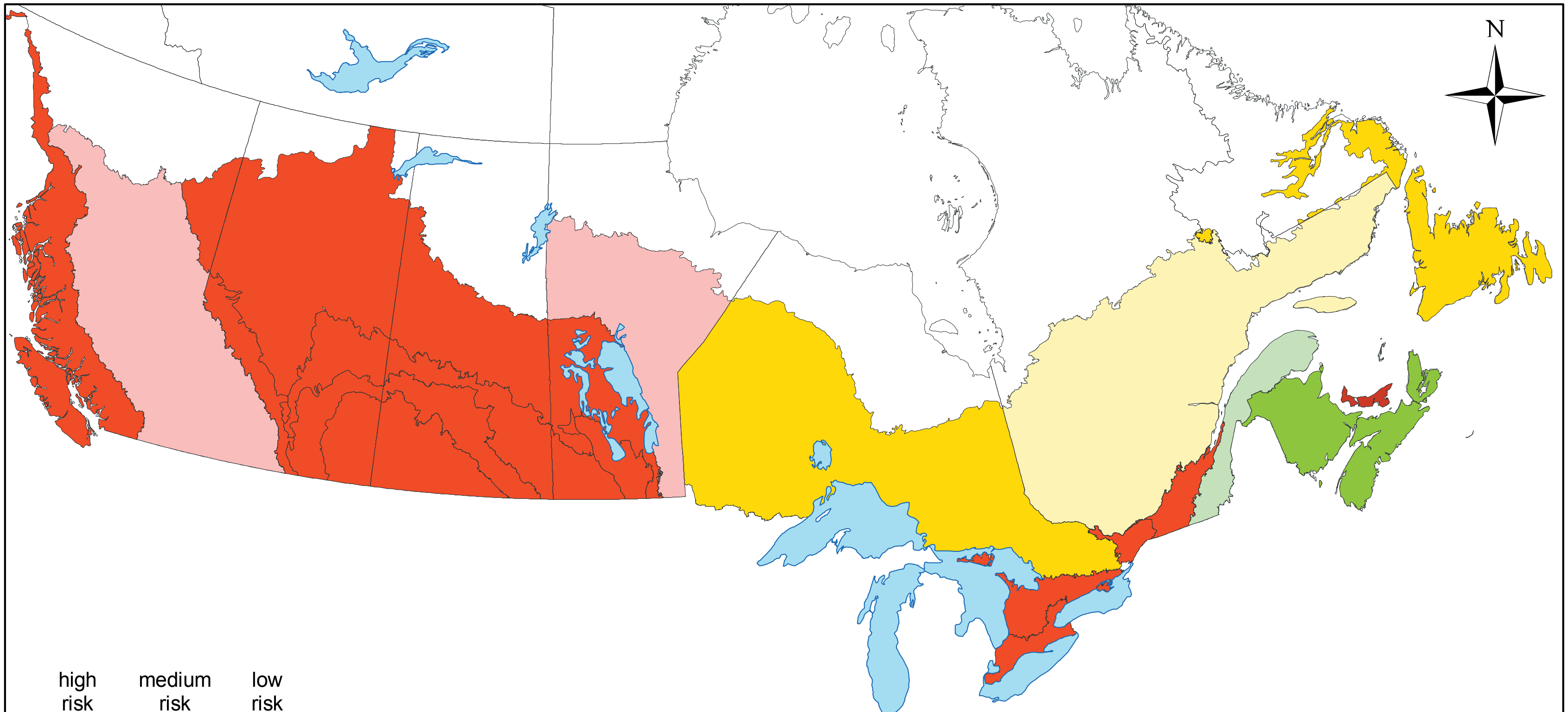


Figure 31: Crop producers: BMP adoption vs. risk to biodiversity

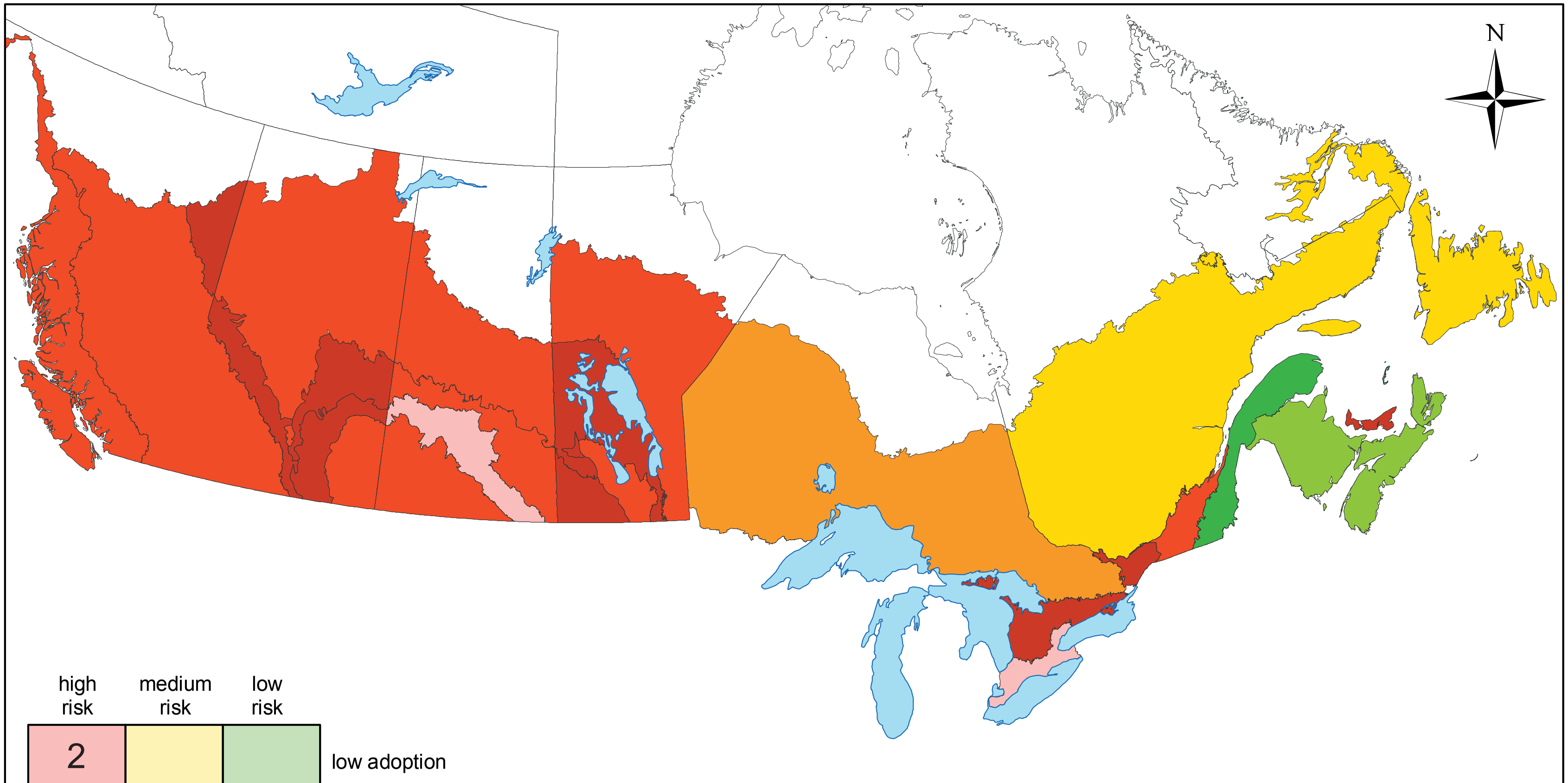


	high risk	medium risk	low risk
low adoption	2	1	1
medium adoption	18	2	2
high adoption	1		

Scale: 1 : 20'000'000
BMP: Beneficial Management Practices
Data from: Farm Environmental Management Survey 2006
Lea Herzig, 26.11. 2009

0 250 500 1,000 Kilometers

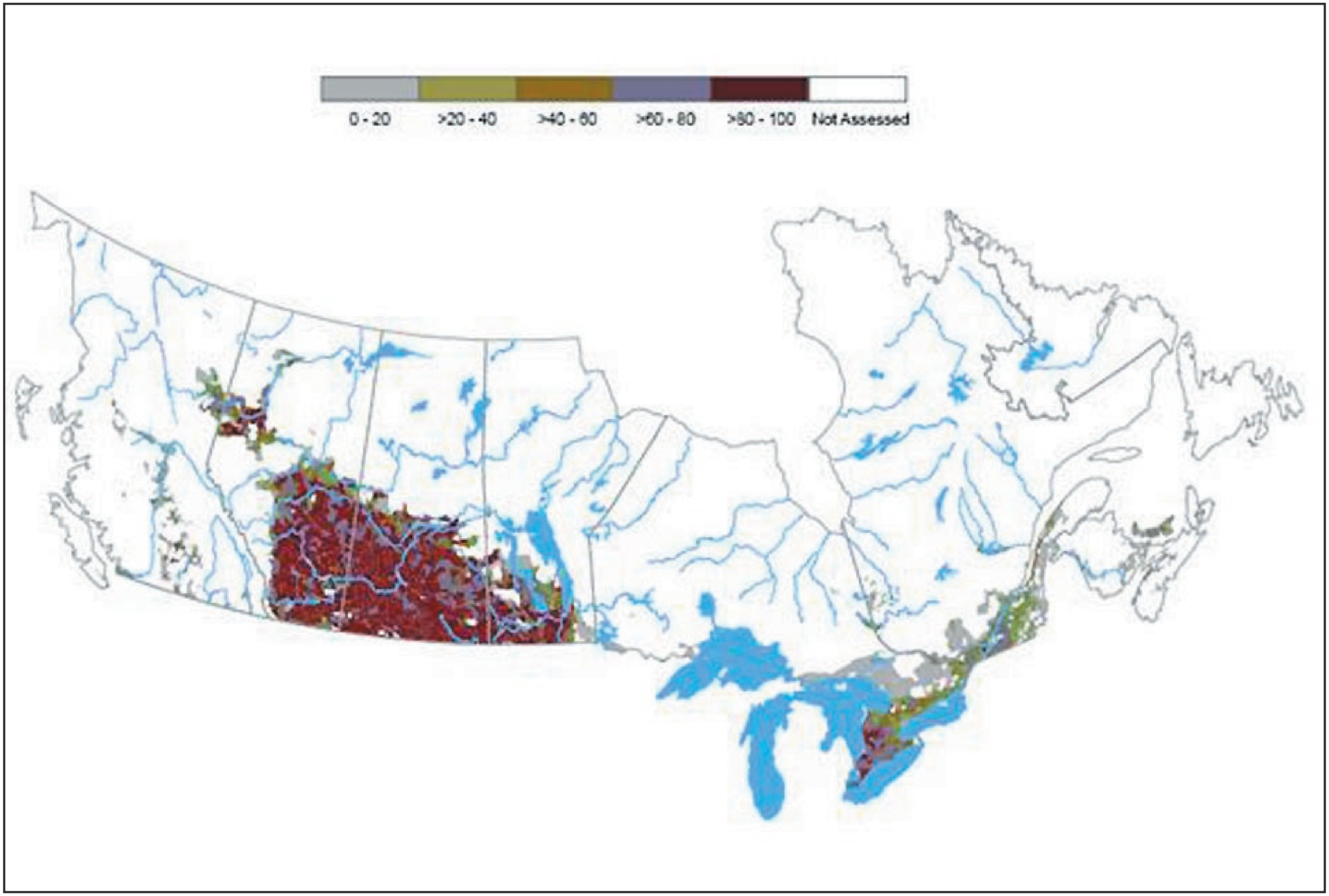
Figure 32: Livestock producers: BMP adoption vs. risk to biodiversity



	high risk	medium risk	low risk
low adoption	2		
medium adoption	10	2	2
high adoption	9	1	1

Scale: 1 : 20'000'000
BMP: Beneficial Management Practices
Data from: Farm Environmental Management Survey 2006
Lea Herzig, 26.11. 2009

Figure 33: Extent of agricultural land in Canada



From: Eilers et al, 2010

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CONCLUSIONS AND FUTURE DIRECTIONS

In this study I highlighted the importance of using science-based information in the agri-environmental policy development process. I developed an indicator, the Beneficial Management Practice (BMP) Adoption Index to fill an existing gap in information that can be used by policy makers to determine where BMPs are being adopted across Canada and identify gaps where more efforts to encourage adoption may be necessary. This tool can also be used to evaluate the success of existing programs aimed at encouraging BMP adoption.

I found that, contrary to my initial hypothesis, BMP adoption in Canada does not appear to be driven by a particular environmental issue or the level of environmental risk in a region. Instead, the results indicate that BMP adoption is relatively higher in areas where agriculture is a dominant land use, where there is a history of agri-environmental issues that have required mitigation, and where there are regulations in place to protect the environment. This information can be useful in developing effective programming to encourage BMP adoption in Canada.

The BMP Adoption Index can now be used to inform policy decisions and identify areas where further analysis may be warranted. For example, in-depth analysis on the drivers and barriers to adoption may be required in areas where BMP adoption is low in order to develop effective policies and programs to increase adoption. Conducting an analysis on existing programs and regulatory instruments in areas where adoption is high may provide insight that can be helpful in building on past successes in areas where adoption is low. Linking the BMP Adoption Index results with socio-economic information such as income, level of education and age may be helpful in targeting programs to ensure they are appropriate for the audience to maximize their effectiveness.

FUTURE DIRECTIONS

This study has highlighted the importance of continued research on the effectiveness of BMPs and their impact on the environment. As well it highlighted a research gap in quantifying cumulative benefits or antagonistic relationships of groups of BMPs. This study was heavily dependent on expert opinion because of the gaps in knowledge on the efficacy of different agricultural practices. As this knowledge increases, further refinements in the accuracy of the rankings may occur. As well, as more information BMP adoption becomes available, the BMP Adoption Index can be refined to allow a more detailed and robust analysis of the level of BMP adoption in Canada. For example, more localized information can allow the BMP Adoption Index to calculate results at a finer scale, or allow reporting by more refined categories, such as livestock or crop type. As well, integrating the results from the 2001 Farm Environmental Management Survey with this data set, and incorporating the results from future surveys can allow for trend analysis so the change in adoption over time can be calculated, providing further information for policy development.

APPENDICES

Appendix 1a

Agriculture Division

2006 Farm Environmental Management Survey

Crops Module

CONFIDENTIAL when completed
Collected under the authority of the Statistics Act, Revised Statutes of Canada, 1985, Chapter S19.

For interviewer use only

Fully completed	005	1	
Partial	005	4	
Refusal	005	2	
No contact	005	3	

In operation	004	00	
Change of operator	004	12	
Out of business	004	13	
Out of scope	004	99	

TO THE RESPONDENT:

Objective of the survey:

Statistics Canada, with Agriculture and Agri-Food Canada, is conducting the Farm Environmental Management Survey in early 2007. This survey will gather information on management practices being used on the farm. The most accurate information about farming comes from producers like you.

The results of the survey will help guide research as well as inform environmental program and policy development in the department. Gathering accurate information on farm management practices will help researchers and policy makers focus efforts and resources on the areas and issues that need it most. Producers will ultimately benefit from such programs to help reduce environmental risk.

This questionnaire is to assist you in answering a telephone survey.

Complete this questionnaire and keep it by your telephone. An interviewer from Statistics Canada will telephone you after **February 11, 2007** for this information.

DO NOT MAIL this questionnaire. Only complete the sections applicable to your operation.

This is a voluntary survey conducted under Section 8 of the Statistics Act. Your cooperation is important to ensure that the information collected in this survey is as accurate as possible.

All information will be kept confidential under the Statistics Act.

Please refer to the calendar year **2006** when answering the questions.

La version française de ce questionnaire est disponible.

5-5100-502.1: 2007-01-23 STC/AGR-450-75054

Statistics Canada Statistique Canada

Canada

Instruction to the respondent:

For all questions about the management practices related to the crop and livestock on your operation, please consider the following:

The following questions deal with ALL LAND OPERATED.

- **Include:** Land rented from other operations and crown or public land used for agricultural purposes.
- **Exclude:** Land rented to other operations.

Review the information on the label. If any information is incorrect or missing, please make the necessary corrections in the boxes below.

FRM

Farm Name (if applicable)

Area Code

NA 1

Surname or Family Name

Telephone

Usual First Name and Initial

ADR

R.R.

Box No.

Number and Street Name

Postal Code

Post Office (name of city, town or village where mail is received)

EML

E-mail Address (if applicable)

Area Code

NA 3

Partner's Name (if applicable)

Telephone

NA 4

Partner's Name (if applicable)

Area Code

COR

Corporation Name (if applicable)

Telephone

5-5100-502.1

2. In 2006, what types of crop did you have on your operation?

(Check all that apply)

	Q2		Q3
(C0201)	☐	**Annual field crops, tame forages, potato and/or summerfallow**	☐ 01
(C0202)	☐	**Fruits**	☐ 02
(C0203)	☐	**Vegetables**	☐ 03
(C0204)	☐	**Greenhouse, nursery, floriculture**	☐ 04
(C0205)	☐	**No crop, only livestock (Go to question 49)**	

3. Which type of crop contributed most to your gross farm receipts?
(C0301)

(Check one only)

5-5100-502.1

Section I. Crop and Nutrient Management

Conventional tillage: Soil disturbance through tillage, planting and other field operations that together incorporate most of the crop residue(less than 30% of the previous crop's residue remains on the surface after planting). Typical implements include discs, mouldboard plough or heavy duty cultivators. Conventional tillage on summerfallow refers to practices which incorporate most of the crop residue prior to winter.

Conservation (or minimum) tillage: Soil disturbance through tillage, planting and other field operations that together retains a considerable portion of the crop residue on the surface (30-60% of the previous crop's residue remains on the surface after planting). Typical implements do not turn the soil over and include chisel plows, soil savers, field cultivators and rodweeders (prairie region). Conservation practices on summerfallow refer to a reduction in the number of passes or the use of implements that retain most of the crop residue on the surface.

No-till, zero-till or direct seeding into undisturbed stubble or sod: No tillage prior to planting (more than 60% of the previous crop's residue remains on the surface after planting). Seeding operations done using implements such as air seeder, air drill or other low disturbance drills or planter. No-till practices on summerfallow refer to the use of only chemicals for weed control (chem-fallow).

4. **What crop was harvested in 2006?** (consider any land in summerfallow in 2006 as a crop type, even if it wasn't harvested) *(If more than 7 crops, report the ones with the largest area)*	5. **What was the area harvested?** (or area of land in summerfallow)	6. **What area was prepared prior to planting using each of the following practices ?** (see definitions above)	7. **What crop was harvested on the majority of that crop area the year before?**
Crop (C0401) 1: _______________	(C0501) ______ (C0502) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents	Conventional (C0601) (C0607) ________ Conservation (C0602) (C0608) ________ No-till (zero-till) (C0603) (C0609) ________ Other (C0606)_________ (C0604) (C0610) ________ Not applicable, no tillage required ○ (C0605)	(C0701) ________ (C0702)
Crop (C0402) 2: _______________	(C0503) ______ (C0504) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents	Conventional (C0611) (C0617) ________ Conservation (C0612) (C0618) ________ No-till (zero-till) (C0613) (C0619) ________ Other (C0616)_________ (C0614) (C0620) ________ Not applicable, no tillage ○ (C0615)	(C0703) ________ (C0704)
Crop (C0403) 3: _______________	(C0505) ______ (C0506) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents	Conventional (C0621) (C0627) ________ Conservation (C0622) (C0628) ________ No-till (zero-till) (C0623) (C0629) ________ Other (C0626)_________ (C0624) (C0630) ________ Not applicable, no tillage required ○ (C0625)	(C0705) ________ (C0706)
Crop (C0404) 4: _______________	(C0507) ______ (C0508) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents	Conventional (C0631) (C0637) ________ Conservation (C0632) (C0638) ________ No-till (zero-till) (C0633) (C0639) ________ Other (C0636)_________ (C0634) (C0640) ________ Not applicable, no tillage required ○ (C0635)	(C0707) ________ (C0708)

5-5100-502.1

4. **What crop was harvested in 2006?** (consider any land in summerfallow in 2006 as a crop type, even if it wasn't harvested) *(If more than 7 crops, report the ones with the largest area)*	5. **What was the area harvested?** (or area of land in summerfallow)	6. **What area was prepared prior to planting using each of the following practices ?** (see definitions above)	7. **What crop was harvested on the majority of that crop area the year before?**
Crop (C0405) 5: _______________	(C0509) ☐ (C0510) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents	Conventional (C0641) (C0647) ________ Conservation (C0642) (C0648) ________ No-till (zero-till) (C0643) (C0649) ________ Other (C0646) ________ (C0644) (C0650) ________ Not applicable, no tillage required ◯ (C0645)	(C0709) ________ (C0710)
Crop (C0406) 6: _______________	(C0511) ☐ (C0512) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents	Conventional (C0651) (C0657) ________ Conservation (C0652) (C0658) ________ No-till (zero-till) (C0653) (C0659) ________ Other (C0656) ________ (C0654) (C0660) ________ Not applicable, no tillage required ◯ (C0655)	(C0711) ________ (C0712)
Crop (C0407) 7: _______________	(C0513) ☐ (C0514) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents	Conventional (C0661) (C0667) ________ Conservation (C0662) (C0668) ________ No-till (zero-till) (C0663) (C0669) ________ Other (C0666) ________ (C0664) (C0670) ________ Not applicable, no tillage required ◯ (C0665)	(C0713) ________ (C0714)

Other field crop (C0408) Other fruit (C0409-C0413) Other vegetable (C0414-C0418)

8. How were the crop residues managed?

(Including straw, pruning material, etc.)

Were the residues... *(Check all that apply)*	**Crops harvested in 2006 (question 4, page 4)**
(C0801) ☐ left on the ground	(C0801/13/25/37/49/61/73) ________
(C0802) ☐ chopped and spread	(C0802/14/26/38/50/62/74) ________
(C0803) ☐ spread without being chopped	(C0803/15/27/39/51/63/75) ________
(C0804) ☐ baled (straw)	(C0804/16/28/40/52/64/76) ________
(C0805) ☐ burned	(C0805/17/29/41/53/65/77) ________
(C0806) ☐ incorporated into the soil	(C0806/18/30/42/54/66/78) ________
(C0807) ☐ composted in a pile	(C0807/19/31/43/55/67/79) ________
(C0808) ☐ collected (chaff portion)	(C0808/20/32/44/56/68/80) ________
(C0809) ☐ grazed by livestock	(C0809/21/33/45/57/69/81) ________
(C0810) ☐ Other, specify: (C0812/24/36/48/60/72/84) ______________	(C0810/22/34/46/58/70/82) ________
(C0811) ☐ Not applicable/no crop residues	(C0811/23/35/47/59/71/83) ________

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9. If you answered "conservation (minimum) tillage" for any of the crops in question 6, when was "conservation (minimum) tillage" <u>first</u> used on the land you operate? (C0901)

01 ○ Prior to 1990 | 02 ○ Between 1990 and 1994 | 03 ○ Between 1995 and 1999

04 ○ After 1999 | 05 ○ Not applicable | 99 ○ Don't know

10. If you answered "no-till, zero-till or direct seeding" for any of the crops in question 6, when was "no-till, zero-till or direct seeding" <u>first</u> used on the land you operate? (C1001)

01 ○ Prior to 1990 | 02 ○ Between 1990 and 1994 | 03 ○ Between 1995 and 1999

04 ○ After 1999 | 05 ○ Not applicable | 99 ○ Don't know

11. Were any commercial fertilizers applied to the land you operated in 2006? (C1101)

- **Exclude** manure

Yes ○ 01

No ○ 03

(Go to question 18)

12. In 2006, what methods were used to apply commercial fertilizers on your crops?

Was it…

(Check all that apply, include application done by you, an employee or custom worker)

(C1201) ☐ applied with seed
(C1202) ☐ subsurface application separate from seeding operation (shovel, knife, bander)
(C1203) ☐ subsurface application during seeding in separate band away from seed (includes mid-row banding)
(C1204) ☐ post-plant or post emergent application (eg. top/side dressing)
(C1205) ☐ surface broadcast and not incorporated
(C1206) ☐ surface broadcast and incorporated
(C1207) ☐ fertigation (fertilizer added to irrigation water)
(C1208) ☐ foliar application
(C1209) ☐ Other, specify: (C1210) ____
☐ Don't know

13. In 2006, what factors were considered when deciding on the amount and type of commercial fertilizer to apply? Was the decision based on…

(Check all that apply)

(C1301) ☐ soil testing
(C1302) ☐ plant analysis (foliar, petiole)
(C1303) ☐ cost of fertilizer/crop prices
(C1304) ☐ soil moisture conditions
(C1305) ☐ nutrient carry over or removal from previous crop or manure
(C1306) ☐ nutrient added by previous legume crop (cover crops, plough down)
(C1307) ☐ nutrient requirement of crop grown
(C1308) ☐ provincial or other guideline/recommendation
(C1309) ☐ advice from consultant/dealer/crop advisor
(C1310) ☐ amount historically used in the past/based on experience
(C1311) ☐ Other, specify: (C1312) ____
☐ Don't know

14. How often is the soil tested for a given field? (C1401)

(If it varied for different fields, give the average)

01 ○ Every year   02 ○ Every 2 to 3 years   03 ○ Every 4 to 5 years
04 ○ Every 6 years or more   05 ○ Do not test soils   99 ○ Don't know

15. In 2006, were commercial fertilizers applied to land that had manure applied to it? (C1501)

Yes ○ 01   No ○ 03
(Go to question 17)

16. If yes, was the amount of commercial fertilizer reduced to offset the nutrient content of manure? (C1601)

Yes ○ 01   No ○ 03   Don't know ○ 99

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Commercial fertilizer application practices

17. For each crop listed in question 4 on page 4, which commercial fertilizer was applied in 2006 and what was the rate and timing of application?

Crop harvested in 2006 (C0401-C0408)	**Commercial fertilizer Applied in 2006** **[N] - [P] - [K]**	**Rate of application** (e.g. 1 litre per acre, kg per ha...) **Quantity**	**Unit of measure**	**Timing of application** 1. <u>Before</u> seeding, at seeding time or <u>before</u> new crop growth begins 2. <u>After</u> seeding, <u>before</u> harvest or <u>after</u> new crop growth begins 3. <u>After</u> harvest *(Check all that apply)*		
Crop 1:_______________	(C1701) a. ___ - ___ - ___	(C1707) ___________	(C1708/09) ___________	☐ 1 (C1710)	☐ 2 (C1711)	☐ 3 (C1712)
	(C1702) b. ___ - ___ - ___	(C1713) ___________	(C1714/15) ___________	☐ 1 (C1716)	☐ 2 (C1717)	☐ 3 (C1718)
	(C1703) c. ___ - ___ - ___	(C1719) ___________	(C1720/21) ___________	☐ 1 (C1722)	☐ 2 (C1723)	☐ 3 (C1724)
	(C1704) d. ___ - ___ - ___	(C1725) ___________	(C1726/27) ___________	☐ 1 (C1728)	☐ 2 (C1729)	☐ 3 (C1730)
Crop 2:_______________	(C1737) a. ___ - ___ - ___	(C1743) ___________	(C1744/45) ___________	☐ 1 (C1746)	☐ 2 (C1747)	☐ 3 (C1748)
	(C1738) b. ___ - ___ - ___	(C1749) ___________	(C1750/51) ___________	☐ 1 (C1752)	☐ 2 (C1753)	☐ 3 (C1754)
	(C1739) c. ___ - ___ - ___	(C1755) ___________	(C1756/57) ___________	☐ 1 (C1758)	☐ 2 (C1759)	☐ 3 (C1760)
	(C1740) d. ___ - ___ - ___	(C1761) ___________	(C1762/63) ___________	☐ 1 (C1764)	☐ 2 (C1765)	☐ 3 (C1766)
Crop 3:_______________	(C1773) a. ___ - ___ - ___	(C1779) ___________	(C1780/81) ___________	☐ 1 (C1782)	☐ 2 (C1783)	☐ 3 (C1784)
	(C1774) b. ___ - ___ - ___	(C1785) ___________	(C1786/87) ___________	☐ 1 (C1788)	☐ 2 (C1789)	☐ 3 (C1790)
	(C1775) c. ___ - ___ - ___	(C1791) ___________	(C1792/93) ___________	☐ 1 (C1794)	☐ 2 (C1795)	☐ 3 (C1796)
	(C1776) d. ___ - ___ - ___	(C1797) ___________	(C1798/99) ___________	☐ 1 (C17100)	☐ 2 (C17101)	☐ 3 (C17102)
Crop 4:_______________	(C17109) a. ___ - ___ - ___	(C17115) ___________	(C17116/117) ___________	☐ 1 (C17118)	☐ 2 (C17119)	☐ 3 (C17120)
	(C17110) b. ___ - ___ - ___	(C17121) ___________	(C17122/123) ___________	☐ 1 (C17124)	☐ 2 (C17125)	☐ 3 (C17126)
	(C17111) c. ___ - ___ - ___	(C17127) ___________	(C17128/129) ___________	☐ 1 (C17130)	☐ 2 (C17131)	☐ 3 (C17132)
	(C17112) d. ___ - ___ - ___	(C17133) ___________	(C17134/135) ___________	☐ 1 (C17136)	☐ 2 (C17137)	☐ 3 (C17138)
Crop 5:_______________	(C17145) a. ___ - ___ - ___	(C17151) ___________	(C17152/153) ___________	☐ 1 (C17154)	☐ 2 (C17155)	☐ 3 (C17156)
	(C17146) b. ___ - ___ - ___	(C17157) ___________	(C17158/159) ___________	☐ 1 (C17160)	☐ 2 (C17161)	☐ 3 (C17162)
	(C17147) c. ___ - ___ - ___	(C17163) ___________	(C17164/165) ___________	☐ 1 (C17166)	☐ 2 (C17167)	☐ 3 (C17168)
	(C17148) d. ___ - ___ - ___	(C17169) ___________	(C17170/171) ___________	☐ 1 (C17172)	☐ 2 (C17173)	☐ 3 (C17174)
Crop 6:_______________	(C17181) a. ___ - ___ - ___	(C17187) ___________	(C17188/189) ___________	☐ 1 (C17190)	☐ 2 (C17191)	☐ 3 (C17192)
	(C17182) b. ___ - ___ - ___	(C17193) ___________	(C17194/195) ___________	☐ 1 (C17196)	☐ 2 (C17197)	☐ 3 (C17198)
	(C17183) c. ___ - ___ - ___	(C17199) ___________	(C17200/201) ___________	☐ 1 (C17202)	☐ 2 (C17203)	☐ 3 (C17204)
	(C17184) d. ___ - ___ - ___	(C17205) ___________	(C17206/207) ___________	☐ 1 (C17208)	☐ 2 (C17209)	☐ 3 (C17210)
Crop 7:_______________	(C17217) a. ___ - ___ - ___	(C17223) ___________	(C17224/225) ___________	☐ 1 (C17226)	☐ 2 (C17227)	☐ 3 (C17228)
	(C17218) b. ___ - ___ - ___	(C17229) ___________	(C17230/231) ___________	☐ 1 (C17232)	☐ 2 (C17233)	☐ 3 (C17234)
	(C17219) c. ___ - ___ - ___	(C17235) ___________	(C17236/237) ___________	☐ 1 (C17238)	☐ 2 (C17239)	☐ 3 (C17240)
	(C17220) d. ___ - ___ - ___	(C17241) ___________	(C17242/243) ___________	☐ 1 (C17244)	☐ 2 (C17245)	☐ 3 (C17246)

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Solid manure application

For the following questions, include all manure applied on the land you operated in 2006 whether produced on your farm, bought or received from others.

18. Was solid manure applied to the land you operated in 2006? (C1801)

Yes ○ 01

No ○ 03 (Go to question 27)

19. On which crop was solid manure applied to on the land you operated in 2006,?

Crop harvested in 2006 (Question 4, page 4):

Crop 1 ______________________________________ (C1901)

Crop 2 ______________________________________ (C1902)

Crop 3 ______________________________________ (C1903)

Crop 4 ______________________________________ (C1904)

Crop 5 ______________________________________ (C1905)

Crop 6 ______________________________________ (C1906)

Crop 7 ______________________________________ (C1907)

Other, specify: (C1908) __________________________ (C1909)

20. How much solid manure was applied on the land you operated in 2006?

Quantity	**Unit of measure**
(C2001) _________________	(C2002/C2003) ________________ (e.g. tons per acre)

21. What was the area on which solid manure was applied to?

Area	**Unit of measure** (C2102)
(C2101) ____________________	01 ○ Acres 02 ○ Hectares 03 ○ Arpents

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22. In 2006, what factors were considered when deciding on the amount of solid manure to apply?

Was the decision based on…

(Check all that apply)

(C2201) ☐ soil testing

(C2202) ☐ soil moisture conditions

(C2203) ☐ nutrient content of manure

(C2204) ☐ nutrient requirement of crop grown

(C2205) ☐ amount historically used

(C2206) ☐ amount of land available to receive supply of manure

(C2207) ☐ nutrient carry over or removal by previous crop

(C2208) ☐ amount of commercial fertilizer applied

(C2209) ☐ distance from the manure storage area

(C2210) ☐ plant analysis (foliage, petiole)

(C2211) ☐ cost of commercial fertilizer

(C2212) ☐ Other, specify: (C2213) ____

☐ Don't know

23. In 2006, was the solid manure tested for its nutrient content before being applied to the land? (C2301)

Yes ◯ 01 No ◯ 03 Don't know ◯ 99

24. Of the total amount of solid manure applied in 2006, what percentage was applied...
(The total should equal 100%)

… **before crop growth began** __________ % (C2401)

… **after crop growth began** __________ % (C2402)

… **after harvest, (before the ground is frozen)** __________ % (C2403)

… **on frozen ground** __________ % (C2404)

(The total should equal 100%)

25. What was the most common method of application of the solid manure? (C2501)

Was it…

01 ◯ broadcast and incorporated into soil

02 ◯ broadcast and not incorporated into soil

03 ◯ Other, specify: (C2502) ______________________

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26. If solid manure was incorporated in the soil, how much time passed between application and incorporation? (C2601)

Was it incorporated…

(If different for different fields, give the average)

01 ◯ the same day of the application
02 ◯ 1-2 days after application
03 ◯ 3-5 days after application
04 ◯ more than 5 days after application
05 ◯ solid manure was not incorporated
99 ◯ Don't know

Liquid and/or semi-solid manure application

27. In 2006, was liquid and/or semi-solid manure applied to the land you operated? (C2701)

Yes ◯ 01

No ◯ 03
(Go to question 36)

28. On which crop was liquid and/or semi-solid manure applied to?

Crop harvested in 2006 (Question 4, page 4):

Crop 1 ______________________________________ (C2801)
Crop 2 ______________________________________ (C2802)
Crop 3 ______________________________________ (C2803)
Crop 4 ______________________________________ (C2804)
Crop 5 ______________________________________ (C2805)
Crop 6 ______________________________________ (C2806)
Crop 7 ______________________________________ (C2807)
Other, specify: (C2808) _________________________ (C2809)

29. How much liquid and/or semi-solid manure was applied on the land you operated in 2006?

Quantity

(C2901) _________________

Unit of measure

(C2902/03) ________________

(e.g. gallons per acre)

30. What was the area on which liquid and/or semi-solid manure was applied to?

Area

(C3001) ____________________

Unit of measure (C3002)

01 ◯ Acres
02 ◯ Hectares
03 ◯ Arpents

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31. In 2006, what factors were considered when deciding on the amount of liquid and/or semi-solid manure to apply?

Was the decision based on …

(Check all that apply)

(C3101) ☐ soil testing
(C3102) ☐ soil moisture conditions
(C3103) ☐ nutrient content of manure
(C3104) ☐ nutrient requirement of crop grown
(C3105) ☐ amount historically used
(C3106) ☐ amount of land available to receive supply of manure
(C3107) ☐ nutrient carry over or removal by previous crop
(C3108) ☐ amount of commercial fertilizer applied
(C3109) ☐ distance from the manure storage area
(C3110) ☐ plant analysis (foliage, petiole)
(C3111) ☐ cost of commercial fertilizer
(C3112) ☐ Other, specify : (C3113) ____
☐ Don't know

32. In 2006, was the liquid and/or semi-solid manure tested for its nutrient content before being applied to the land? (C3201)

Yes ○ 01 No ○ 03 Don't know ○ 99

33. Of the total amount of liquid and/or semi-solid manure applied in 2006, what percentage was applied...
(The total should be equal to 100%)

… **before crop growth began** __________ % (C3301)

… **after crop growth began** __________ % (C3302)

… **after harvest, (before the ground is frozen)** __________ % (C3303)

… **on frozen ground** __________ % (C3304)

(The total should equal 100%)

34. What was the most common method of application of the liquid and/or semi-solid manure?

Was it…

01 ☐ broadcast and incorporated into soil
02 ☐ broadcast and not incorporated into soil
03 ☐ directly injected into soil
04 ☐ applied below crop canopy or using low boom applicator
05 ☐ applied using irrigation system (e.g. with a pivot gun)
06 ☐ Other, specify: (C3402) _______________________
99 ☐ Don't know

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35. If liquid and/or semi-solid manure was incorporated in the soil, how much time passed between application and incorporation? (C3501)

Was it incorporated…

(If different for different fields, give the average)

01 ☐ the same day of the application

02 ☐ 1-2 days after application

03 ☐ 3-5 days after application

04 ☐ more than 5 days after application

☐ liquid and/or semi-solid manure was not incorporated

99 ☐ Don't know

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Section II - Pesticide Application Practices

36. In 2006, were any herbicides applied to the land you operated? (C3601)

Yes ○ 01

No ○ 03 (Go to question 38)

Don't know ○ 99 (Go to question 38)

37. If yes, on which crop was it applied?

Crop harvested in 2006 (Question 4, page 4):

Crop 1 ___________________________ (C3701)

Crop 2 ___________________________ (C3702)

Crop 3 ___________________________ (C3703)

Crop 4 ___________________________ (C3704)

Crop 5 ___________________________ (C3705)

Crop 6 ___________________________ (C3706)

Crop 7 ___________________________ (C3707)

38. In 2006, were any insecticides applied to the land you operated? (C3801)

Yes ○ 01

No ○ 03 (Go to question 40)

Don't know ○ 99 (Go to question 40)

39. If yes, on which crop was it applied?

Crop harvested in 2006 (Question 4, page 4):

Crop 1 ___________________________ (C3901)

Crop 2 ___________________________ (C3902)

Crop 3 ___________________________ (C3903)

Crop 4 ___________________________ (C3904)

Crop 5 ___________________________ (C3905)

Crop 6 ___________________________ (C3906)

Crop 7 ___________________________ (C3907)

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40. In 2006, were any fungicides applied to the land you operated? (C4001)

Yes ○ 01

No ○ 03 (Go to question 42)

Don't know ○ 99 (Go to question 42)

41. If yes, on which crop was it applied?

Crop harvested in 2006 (Question 4, page 4):

Crop 1 ___________________________ (C4101)

Crop 2 ___________________________ (C4102)

Crop 3 ___________________________ (C4103)

Crop 4 ___________________________ (C4104)

Crop 5 ___________________________ (C4105)

Crop 6 ___________________________ (C4106)

Crop 7 ___________________________ (C4107)

42. In 2006, what factors were considered when deciding to apply herbicides, insecticides, fungicides?

Was the decision based on *(Check all that apply)*	**Herbicides**	**Insecticides**	**Fungicides**
... experience/regularly scheduled application	☐ (C4201)	☐ (C4213)	☐ (C4225)
…seed purchased (included with treated seed)	☐ (C4202)	☐ (C4214)	☐ (C4226)
…crop or weed growth stage	☐ (C4203)	☐ (C4215)	☐ (C4227)
…scouting (at the first sign of weeds, insects or disease on farm)	☐ (C4204)	☐ (C4216)	☐ (C4228)
…regional forecasting/warning services	☐ (C4205)	☐ (C4217)	☐ (C4229)
…economic injury threshold (weed, insects or disease impact exceeds acceptable levels)	☐ (C4206)	☐ (C4218)	☐ (C4230)
…climatic conditions (degree days, moisture)	☐ (C4207)	☐ (C4219)	☐ (C4231)
…advice from other farm operators	☐ (C4208)	☐ (C4220)	☐ (C4232)
…advice from seed or chemical salesperson, agronomist	☐ (C4209)	☐ (C4221)	☐ (C4233)
…established integrated pest management program	☐ (C4210)	☐ (C4222)	☐ (C4234)
Other, specify: ______________________________ (C4212/24/36)	☐ (C4211)	☐ (C4223)	☐ (C4235)
Don't know	☐	☐	☐

43. In 2006, did a formally certified (or licensed) person apply or supervise application of herbicides, insecticides or fungicides on your operation? (C4301)
(Include application done by farm operator, partner, employees or custom applicator)

01 ◯ Yes, all applications

02 ◯ Yes, some applications

03 ◯ No

99 ◯ Don't know

44. In 2006, when was the sprayer used to apply herbicides, insecticides or fungicides calibrated?
(if more than one sprayer, answer for the one used most frequently)

Was it calibrated …
(Check all that apply)

(C4401) ☐ only when it broke down or when major components were replaced

(C4402) ☐ before the beginning of the crop season / before first application

(C4403) ☐ between applications of different types of pesticides

(C4404) ☐ Did not calibrate

(C4405) ☐ Other, specify: (C4407) ______________________________

☐ Don't know

(C4406) ☐ Not applicable / no sprayer used

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45. In 2006, were any of the following methods used to control herbicide, insecticide or fungicide drift on your operation?

Did you, a partner, an employee or custom applicator…

(Check all that apply)

(C4501) ☐ apply pesticides only when winds are below recommended thresholds for application rate/wind speed

(C4502) ☐ use low drift or low pressure nozzles

(C4503) ☐ use shrouded booms (protective shrouds or cones around sprayer boom)

(C4504) ☐ add anti-drift agents or chemical to the herbicides, insecticides or fungicides

(C4505) ☐ leave untreated buffer zones

(C4506) ☐ Other, specify: (C4508) ____

(C4507) ☐ No specific method employed to control pesticide drift

☐ Don't know

46. In 2006, were any of the following methods used to reduce the amount of herbicides, insecticides or fungicides used on your operation?

Did you, a partner, an employee or custom applicator …

(Check all that apply)

(C4601) ☐ use tracking, guidance or marking (flags) systems to minimize overlap and misses

(C4602) ☐ spray only target infested areas (including field margins)

(C4603) ☐ use in line injection/mixing systems to eliminate unused tank mixes

(C4604) ☐ apply smaller amounts than rate recommended on chemical product label

(C4605) ☐ Other, specify: (C4607) ____

(C4606) ☐ No specific method employed to reduce the amount of herbicides, insecticides or fungicides

☐ Don't know

Alternative methods to control weeds, insects or diseases

47. In 2006, were any of the following methods used specifically to control weeds, insects or diseases?

Did you, a partner, an employee or custom applicator …

(Check all that apply)

(C4701) ☐ plant tolerant or resistant plants, varieties or cultivars (e.g. BT corn)

(C4702) ☐ rotate crops to disrupt pest cycles

(C4703) ☐ eliminate, remove or incorporate diseased plant, pruning residues or cull piles

(C4704) ☐ plant green manure or cover crops

(C4705) ☐ plant in the fall (e.g. winter wheat, fall rye, tamed pasture)

(C4706) ☐ use tillage implements (e.g. cultivator, rotary hoe)

(C4707) ☐ use hand weeding/hoeing

(C4708) ☐ use covers or mulches (synthetic or natural crop residues)

(C4709) ☐ introduce natural enemies/biological control agents (predators, parasites, pathogens, pheromones)

(C4710) ☐ lure or trap crops

(C4711) ☐ Other, specify: (4712) ____

☐ Don't know

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Section III - Land and Water Management Practices

48. In 2006, were any of the following practices used on the land you operated?
If yes, specify the area for each practice used.

Did you use… *(Check all that apply)*	**Area**	**Unit of measure**
(C4801) ☐ cover or companion crops seeded (within an existing row "relay cropped" or solid seeded crop "intercropped")	(C4802) __________	(C4803) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
(C4804) ☐ winter cover or green manure crops seeded alone after previous crop harvest	(C4805) __________	(C4806) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
(C4807) ☐ strip cropping	(C4808) __________	(C4809) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
(C4810) ☐ contour or across the slope cropping	(C4811) __________	(C4812) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
(C4813) ☐ terracing (large soil ridges constructed on the contour or across the slope)	(C4814) __________	(C4815) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
(C4816) ☐ permanent perennial forages on erodible land	(C4817) __________	(C4818) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
(C4819) ☐ straw mulching (spread straw) on erodible land	(C4820) __________	(C4821) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
(C4822) ☐ farmstead shelterbelts/ windbreaks	(C4823) __________	(C4824) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
(C4825) ☐ field shelterbelts (trees, shrubs)	(C4826) __________	(C4827) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
(C4828) ☐ land with surface or subsurface drainage (e.g. constructed surface water channels or tile drainage)	(C4829) __________	(C4830) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
(C4831) ☐ Other, specify: (C4832) ___________________________	(C4833) __________	(C4834) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents

The following questions are about land use changes.
Woodlands include woodlots, sugarbush, tree windbreaks, bushes, shelterbelts. (C4901-4904)

	Area	**Unit of measure**
49. In 2006, what was the total woodland area on your operation?	(C4905) __________	(C4906) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
50. Over the last five years, how much land area was changed FROM woodland TO pasture or cultivated cropland?	(C5001) __________	(C5002) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
51. Over the last five years, how much land area was changed FROM pasture or cultivated cropland TO woodland?	(C5101) __________	(C5102) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
52. In 2006, how much land area was changed FROM cultivated cropland TO pasture?	(C5201) __________	(C5202) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents
53. In 2006, how much land area was changed FROM pasture (tame, seeded and natural) TO cultivated cropland?	(C5301) __________	(C5302) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents

5-5100-502.1

Different types of wetlands *may be distinguished by the amount of time they normally contain surface water and by the different plant communities they harbour. Temporary wetlands usually contain water only for a short time in the spring or after heavy precipitation.*

Seasonal wetlands *normally have water present until mid summer or early fall, and during most years. Examples include ponds, sloughs, potholes, seasonally flooded meadows, marshes and treed wet swamps.*

Permanent wetlands *are flooded year-round except for extreme drought periods.*

Riparian buffer area *includes both permanent planted or natural vegetation adjacent to a seasonal or permanent wetland or waterway, extending upslope from the normal shoreline.*

Setback distance *is the distance between the normal shoreline of a seasonal or permanent wetland or waterway, extending upslope to the edge of manure, fertilizer or pesticide applications.*

54. Were there any seasonal wetlands on or adjacent to the land you operated in 2006? (C5401)

Yes ◯ 01 | No ◯ 03 (Go to question 61) | Don't know ◯ 99 (Go to question 61)

55. If yes, what was the total area of the seasonal wetlands?

(C5501) ____________________ (C5502) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents

56. Did you maintain a riparian buffer area around the seasonal wetlands? (C5601)

Yes ◯ 01 | No ◯ 03 (Go to question 58)

57. If yes, how wide was it? (If it varied for different wetlands, give the average width)

(C5701) ________________ (C5702) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards

58. Did you maintain a setback distance around the seasonal wetlands? (C5801)

Yes ◯ 01 | No ◯ 03 (Go to question 60)

59. If yes, how wide was it? (If it varied for different wetlands, give the average width)

(C5901) ______________ (C5902) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards

60. Did you stabilize shorelines or banks to prevent erosion? (C6001)

Yes ◯ 01 | No ◯ 03 | Don't know ◯ 99

61. **Were there any <u>permanent</u> wetlands on or adjacent to the land you operated in 2006?** (C6101)

Yes ○ 01

No ○ 03 (Go to question 68)

Don't know ○ 99 (Go to question 68)

62. **If yes, what was the total area of the <u>permanent</u> wetlands?**

(C6201) ________________ (C6202) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents

63. **Did you maintain a riparian buffer area around the <u>permanent</u> wetlands?** (C6301)

Yes ○ 01

No ○ 03 (Go to question 65)

64. **If yes, how wide was it?** (If it varied for different wetlands, give the average width)

(C6401) _______________ (C6402) 01 ○ Feet 02 ○ Metres 03 ○ Yards

65. **Did you maintain a setback distance around the <u>permanent</u> wetlands?** (C6501)

Yes ○ 01

No ○ 03 (Go to question 67)

66. **If yes, how wide was it?** (If it varied for different wetlands, give the average width)

(C6601) __________________ (C6602) 01 ○ Feet 02 ○ Metres 03 ○ Yards

67. **Did you stabilize shorelines or banks to prevent erosion?** (C6701)

Yes ○ 01

No ○ 03

Don't know ○ 99

5-5100-502.1

Waterways *include grassed waterways, coulees, treed waterways, ditches, creeks, streams.*

Riparian buffer area *includes permanent natural or planted vegetation adjacent to surface water.*

Setback distance/separation *is distance between surface water and manure, fertilizer or pesticides applications.*

68. Were there any waterways on or adjacent to the land you operated in 2006? (6801)

Yes ○ 01 — No ○ 03 (Go to question 75) — Don't know ○ 99 (Go to question 75)

69. If yes, what was the total LENGTH of the waterways?

(C6901) _______________ (C6902) 01 ○ Feet 02 ○ Metres 03 ○ Yards 04 ○ Miles 05 ○ Kilometres

70. Did you maintain a riparian buffer area around the waterways? (C7001)

Yes ○ 01 — No ○ 03 (Go to question 72)

71. If yes, how wide was it? (If it varied for different waterways, give the average width)

(C7101) _______________ (C7102) 01 ○ Feet 02 ○ Metres 03 ○ Yards

72. Did you maintain a setback distance from the waterways? (C7201)

Yes ○ 01 — No ○ 03 (Go to question 74)

73. If yes, how wide was it? (If it varied for different waterways, give the average width)

(C7301) ________________ (C7302) 01 ○ Feet 02 ○ Metres 03 ○ Yards

74. Did you stabilize shorelines or banks to prevent erosion? (C7401)

Yes ○ 01 — No ○ 03 — Don't know ○ 99

5-5100-502.1

Domestic Water

75. In 2006, were there any active water wells on the land you operated? (C7501)

Yes ○ 01

No ○ 03 (Go to question 77)

Don't know ○ 99 (Go to question 77)

76. If yes, how often is the water tested to meet quality standards for human and/or livestock consumption? (C7601)

(If it varied for different wells, give the average)

01 ○ At least once a year

02 ○ Every 2 years

03 ○ Every 3 to 5 years

04 ○ Every 6 years or more

05 ○ Not tested, not a concern

06 ○ Never

99 ○ Don't know

77. In 2006, were there any abandoned water wells on the land you operated? (C7701)

Yes ○ 01

No ○ 03 (Go to question 79)

Don't know ○ 99 (Go to question 79)

78. If yes, have these abandoned wells been decommissioned? (C7801)

(wells filled in, capped)

01 ○ All decommissioned

02 ○ Some decommissioned

03 ○ None

99 ○ Don't know

5-5100-502.1

Section IV - Wildlife Damage

79. In the last 5 years, were any damages caused to the CROPS on your operation by any of the following wildlife groups?

(Check all that apply)

(C7901) ☐ Waterfowl (ducks, geese, cranes)

(C7902) ☐ Ungulates (deer, moose, elk)

(C7903) ☐ Other birds (blackbird, starling, crows)

(C7904) ☐ Raccoons

(C7905) ☐ Bears

(C7906) ☐ Rodents and small animals (gophers, badgers, moles, porcupines)

(C7907) ☐ Other, specify: (C7909) ____

(C7908) ☐ No damage caused by wildlife on my operation (Go to question 81)

80. In 2006, what crops were damaged, and what percentage of the crop was lost or damaged?

Yield lost expressed in percent, not in dollar value.

Crop harvested in 2006 *(question 4, page 4)*	**Specify percentage of crop that was damaged**			
	0%-5%	6%-10%	11%-30%	31% or more
Crop 1 ____________________________ (C8001)	(C8002) 01 ◯	02 ◯	03 ◯	04 ◯
Crop 2 ____________________________ (C8003)	(C8004) 01 ◯	02 ◯	03 ◯	04 ◯
Crop 3 ____________________________ (C8005)	(C8006) 01 ◯	02 ◯	03 ◯	04 ◯
Crop 4 ____________________________ (C8007)	(C8008) 01 ◯	02 ◯	03 ◯	04 ◯
Crop 5 ____________________________ (C8009)	(C8010) 01 ◯	02 ◯	03 ◯	04 ◯
Crop 6 ____________________________ (C8011)	(C8012) 01 ◯	02 ◯	03 ◯	04 ◯
Crop 7 ____________________________ (C8013)	(C8014) 01 ◯	02 ◯	03 ◯	04 ◯

81. In the last 5 years, were any of the following practices used to reduce the impact of wildlife damage to your crops?

(Check all that apply)

(C8101) ☐ Fencing to protect crops

(C8102) ☐ Scaring devices or repellent systems

(C8103) ☐ Shooting or trapping by yourself or others

(C8104) ☐ Lure crops

(C8105) ☐ Less palatable crops

(C8106) ☐ Border cropping

(C8107) ☐ Netting

(C8108) ☐ Other, specify: (C8110) ____

(C8109) ☐ No practices used specifically to reduce the impact of wildlife damage

82. In the last 5 years, was there any damage to BUILDINGS/EQUIPMENT on your operation caused by wildlife? (C8201)

Yes ◯ 01

No ◯ 03

(Go to question 84)

83. If yes, what was the damage?

Specify: (C8301) ____

84. In the last 5 years, did your operation receive any payments for the following purposes?

(Check all that apply)

(C8401) ☐ Financial compensation for wildlife damage

(C8402) ☐ Financial compensation for conservation of wildlife habitats

(C8403) ☐ Payments for the purchase of land or for easement by wildlife conservation organizations

(C8404) ☐ Payments for land use/management agreement

(C8405) ☐ None of the above

Section V - Waste Management and Hazardous Materials

85. In 2006, how were the following materials stored on your farm operation?

(Check all that apply)	Commercial Fertilizers	Pesticides *(Insecticides, Herbicides, Fungicides)*	Petroleum Products: Fuel	Petroleum Products: Oil and Grease
Building with a concrete floor or pad	☐ (C8501)	☐ (C8507)	☐ (C8513)	☐ (C8519)
Building without a concrete floor or pad	☐ (C8502)	☐ (C8508)	☐ (C8514)	☐ (C8520)
Above ground sealed tank	☐ (C8503)	☐ (C8509)	☐ (C8515)	☐ (C8521)
Other, specify:_______________________ (C8306/12/18/24)	☐ (C8504)	☐ (C8510)	☐ (C8516)	☐ (C8522)
Not stored on the farm operation	☐ (C8505)	☐ (C8511)	☐ (C8517)	☐ (C8523)

	Commercial Fertilizers	Pesticides *(Insecticides, Herbicides, Fungicides)*	Petroleum Products: Fuel	Petroleum Products: Oil and Grease
86. Did the storage site have a containment system to handle spills?	(C8601) 01 ◯ Yes 03 ◯ No 04 ◯ N/A	(C8602) 01 ◯ Yes 03 ◯ No 04 ◯ N/A	(C8603) 01 ◯ Yes 03 ◯ No 04 ◯ N/A	(C8604) 01 ◯ Yes 03 ◯ No 04 ◯ N/A

87. In 2006, how were these products (including their containers) disposed of? Were they disposed of …

(Check all that apply)	Commercial Fertilizers	Pesticides *(Insecticides, Herbicides, Fungicides)*	Petroleum Products *(e.g. oil, grease)*	Other Hazardous Materials *(e.g. batteries, paint)*
… on farm (incineration, buried, etc.)	☐ (C8701)	☐ (C8709)	☐ (C8717)	☐ (C8725)
… with domestic garbage	☐ (C8702)	☐ (C8710)	☐ (C8718)	☐ (C8726)
… in a municipal recycling program	☐ (C8703)	☐ (C8711)	☐ (C8719)	☐ (C8727)
… by returning to supplier	☐ (C8704)	☐ (C8712)	☐ (C8720)	☐ (C8728)
… using waste disposal sites for hazardous waste or dangerous goods	☐ (C8705)	☐ (C8713)	☐ (C8721)	☐ (C8729)
Other, specify : ______________________ (C8508/16/24/32)	☐ (C8706)	☐ (C8714)	☐ (C8722)	☐ (C8730)
No disposal	☐ (C8707)	☐ (C8715)	☐ (C8723)	☐ (C8731)

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Wastewater *includes water to wash produce, milkhouse, pens or facilities, silage leakage, run-off water from livestock pens, etc.*

88. In 2006, how was wastewater managed on your operation? Was it…

(Check all that apply)

(C8801) ☐ discharged to a constructed retention pond or holding pond

(C8802) ☐ discharged to a septic or sewer system

(C8803) ☐ discharged into a filtration marsh or wetland

(C8804) ☐ included in the liquid manure system

(C8805) ☐ collected in holding or storage tank

(C8806) ☐ Other, specify: (C8808) ________________________________

(C8807) ☐ Not actively managed. Wastewater removed through natural drainage

89. In 2006, were there any livestock or poultry on your operation? (C8901-C8907)

Yes ○ 01 No ○ 03

(Go to question 91)

90. In 2006, how many animals were disposed of using each of the following methods?

On farm:	Dairy cattle	Beef cattle	Hogs	Poultry
Buried	________(C9001)	________(C9007)	________(C9013)	________(C9019)
Incinerated	________(C9002)	________(C9008)	________(C9014)	________(C9020)
Composted	________(C9003)	________(C9009)	________(C9015)	________(C9021)
Other, specify: ________ (C9005/11/17/23/29)	________(C9004)	________(C9010)	________(C9016)	________(C9022)
Off farm collection service (e.g. rendering enterprise)	________(C9006)	________(C9012)	________(C9018)	________(C9024)

On farm:	**Other, livestock** specify:	**Number**
Buried	________________	________________ (C9025)
Incinerated	________________	________________ (C9026)
Composted	________________	________________ (C9027)
Other, specify: ________ (C9005/11/17/23/29)	________________	________________ (C9028)
Off farm collection service (e.g. rendering enterprise)	________________	________________ (C9030)

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Section VI - Environmental Farm Plan

91. Does your farm operation have a formal, written Environmental Farm Plan (EFP)? (C9101)
(e.g. < relevant provincial plan > as part of a federal, provincial or industry program.)

A formal, written farm environmental farm plan is an overall assessment of environmental issues or concerns related to your operation, and can include Individual and/or Group planning processes.

Yes, plan is developed ○ 01

Yes, plan is in development or being reviewed ○ 02

No ○ 03 (Go to question 96)

92. When was this Environmental Farm Plan (EFP) developed or last updated? (C9201)

01 ○ Less than 1 year ago

02 ○ From 1 to 3 years ago

03 ○ From 3 to 5 years ago

04 ○ More than 5 years ago

93. To what extent were the Beneficial Management Practices (BMPs) identified in the action plan of your EFP implemented on your operation? (C9301)

01 ○ Practices fully implemented

02 ○ Practices partially implemented

03 ○ Practices not implemented

94. Was any technical assistance received from any of the following groups to help implement the Beneficial Management Practices (BMPs) identified in the action plan of your EFP?

(Check all that apply)

(C9401) ☐ Did not receive assistance

(C9402) ☐ Government agency

(C9403) ☐ Industry (input supplier, processors, etc.)

(C9404) ☐ Environmental non-governmental organizations

(C9405) ☐ Producer association

(C9406) ☐ College/University

(C9407) ☐ EFP planning advisor/facilitator

(C9408) ☐ Agrologist

(C9409) ☐ Other, specify: (C9410) ________________________

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95. Was any financial assistance (from any source) received to offset costs for implementation of Beneficial Management Practices (BMPs) identified in the action plan of your EFP? (C9501)

(Exclude drought payments)

Yes ◯ 01 No ◯ 03

96. In 2006, were global positioning system (GPS) equipment or products (digital maps) used on your operation? (C9601)

Yes ◯ 01

No ◯ 03 (Go to question 98)

Don't know ◯ 99 (Go to question 98)

97. If yes, was it used …

(Check all that apply)

(C9701) ☐ to collect information for soil and crop management

(C9702) ☐ to collect information for water management

(C9703) ☐ as a tracking or guidance system on tractor to eliminate overlaps and misses in field operations

(C9704) ☐ to target or vary fertilizer or manure application rate

(C9705) ☐ to target or vary pesticide application rates

(C9706) ☐ Other, specify: (C9707) ___________________________________

Section VI - Data sharing agreement

Thank you for taking the time to participate in our survey. To reduce response burden and to ensure more uniform statistics, Statistics Canada has entered into an agreement under section 12 of the Statistics Act with Agriculture and Agri-Food Canada, and the ministry/department of agriculture of the provinces of Québec, Ontario and Alberta, for the sharing of information from this survey. Also, for the Québec residents only, Statistics Canada has entered into an agreement under section 12 of the Statistics Act with the Institut de la statistique du Québec. Statistics Canada will not share your name, address or other identifying information. The information is required to be kept confidential and used only for statistical and research purposes.

98. Do you agree to share the information on this survey with Agriculture and Agri-Food Canada? (C9801)

Yes ◯ 01 No ◯ 03

99a. If you are a resident of Ontario or Alberta, do you agree to share the information on this survey with your provincial ministry/department of agriculture? (C9901)

Yes ◯ 01 No ◯ 03

99b. If you are a resident of Québec, do you agree to share the information on this survey with the Ministère de l'Agriculture, de l'Alimentation et des Pêcheries du Québec and the Institut de la statistique du Québec?

Yes ◯ 01 No ◯ 03

In order to extend the research capabilities of this survey, Statistics Canada intends to combine the information from this survey with the information your operation provided on the 2006 Census of Agriculture. Your operation's 2006 Census of Agriculture information will only be used by Statistics Canada and will not be shared.

100. Do you agree that Statistics Canada may combine the information from this survey with the information you provided on the 2006 Census of Agriculture? (C10001)

Yes ◯ 01 No ◯ 03

Comments: (C10112)

Thank you for your cooperation.

5-5100-502.1

Appendix 1b

Agriculture Division

2006 Farm Environmental Management Survey
Livestock Module

CONFIDENTIAL when completed
Collected under the authority of the Statistics Act, Revised Statutes of Canada, 1985, Chapter S19.

For interviewer use only

Fully completed	005	1	
Partial	005	4	
Refusal	005	2	
No contact	005	3	

In operation	004	00	
Change of operator	004	12	
Out of business	004	13	
Out of scope	004	99	

TO THE RESPONDENT:

Objective of the survey:

Statistics Canada, with Agriculture and Agri-Food Canada, is conducting the Farm Environmental Management Survey in early 2007. This survey will gather information on management practices being used on the farm. The most accurate information about farming comes from producers like you.

The results of the survey will help guide research as well as inform environmental program and policy development in the department. Gathering accurate information on farm management practices will help researchers and policy makers focus efforts and resources on the areas and issues that need it most. Producers will ultimately benefit from such programs to help reduce environmental risk.

This questionnaire is to assist you in answering a telephone survey.

Complete this questionnaire and keep it by your telephone. An interviewer from Statistics Canada will telephone you after **February 11, 2007** for this information.

DO NOT MAIL this questionnaire. Only complete the sections applicable to your operation.

This is a voluntary survey conducted under Section 8 of the Statistics Act. Your cooperation is important to ensure that the information collected in this survey is as accurate as possible.

All information will be kept confidential under the Statistics Act.

Please refer to the calendar year **2006** when answering the questions.

La version française de ce questionnaire est disponible.

5-5100-503.1: 2007-01-23 STC/AGR-450-75054

Statistics Canada Statistique Canada

Canada

Instructions to respondents:

For all questions about the management practices related to the crop and livestock on your operation, please consider the following:

- Practices related to all livestock on your operation, regardless of ownership, including those that are boarded, custom fed or fed under contract and pastured for others.
- Practices related to all livestock owned by you and held on crown land, community pastures and grazing projects.
- All practices related to the land on your operation whether the land area is owned, rented or crop-shared **FROM OTHERS** in 2006.
- Do not report livestock owned by you but kept on a farm, ranch or feedlot operated by someone else.
- Do not report practices on the land rented **TO OTHERS** in 2006.

Review the information on the label. If any information is incorrect or missing, please make the necessary corrections in the boxes below.

FRM | Farm Name (if applicable) | Area Code

NA 1 | Surname or Family Name | Telephone -

Usual First Name and Initial

ADR | R.R. | Box No. | Number and Street Name

Postal Code | Post Office (name of city, town or village where mail is received)

EML | E-mail Address (if applicable)

Area Code

NA 3 | Partner's Name (if applicable) | Telephone -

NA 4 | Partner's Name (if applicable) | Area Code

COR | Corporation Name (if applicable) | Telephone -

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2. **In 2006, what types of livestock or poultry production did you have on your operation?** (Report all animals on this operation, regardless of ownership, including those that are boarded, custom-fed or fed under contract. Exclude animals owned but kept on another farm or ranch operated by someone else)		3. **Which type of livestock or poultry production contributed most to your gross farm receipts?** (C0301)
(Check all that apply)		*(Check one only)*
(C0201) ☐	**Dairy cattle and/or milk production** (breeding bulls, cows, replacements, dairy heifers and dairy calves)	○ 01
(C0202) ☐	**Beef cattle including feedlot** (bulls, cows, beef heifers, steers and beef calves)	○ 02
(C0203) ☐	**Pork production** (boars, sows for breeding, bred gilts and all other pigs)	○ 03
(C0204) ☐	**Poultry and/or egg production** (broilers, roasters, laying hens, chicks intended for laying, turkeys, ducks and geese)	○ 04
(C0205) ☐	**Other livestock or poultry production - specify:** (C0207) ______________________ (exclude household pets) (C0208) ______________________	○ 05 ○ 06
(C0206) ☐	**Crops only, no livestock or poultry production (Go to question 49)**	

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Section I. Livestock Inventories and Buildings

4. In 2006, were there any livestock kept <u>permanently</u> outside of building on your operation? (C0401)

Yes ◯ 01 No ◯ 03

(Go to question 6)

5. In 2006, how many and what type of livestock or poultry were kept permanently outside?

Cattle and calves	Calves, under 1 year old	_______________	(C0501)
	Steers, 1 year and over	_______________	(C0502)
	Heifers, 1 year and over	_______________	(C0503)
	Cows	_______________	(C0504)
	Bulls, 1 year and over	_______________	(C0505)
Other livestock or poultry (bison, llamas, deer, elk, etc., exclude wild animals)	specify: _________________________	_______________	(C0506)
	_________________________	_______________	(C0507)

6. In 2006, were there any buildings where livestock was housed on your operation? (C0601)

Yes ◯ 01 No ◯ 03

(Go to question 12)

7. In 2006, how many livestock buildings were on your operation?
(Exclude calf hutches)

Number of buildings where livestock were housed: ____________ (C0701)

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8. **In 2006, on average how many livestock or poultry were housed in each livestock building?**

	Building 1	Building 2	Building 3	Building 4	Building 5
CATTLE AND CALVES:					
Calves, under 1 year old	(C0801) _______	(C0816) _______	(C0831) _______	(C0846) _______	(C0861) _______
Steers, 1 year and over	(C0802) _______	(C0817) _______	(C0832) _______	(C0847) _______	(C0862) _______
Heifers, 1 year and over	(C0803) _______	(C0818) _______	(C0833) _______	(C0848) _______	(C0863) _______
Cows	(C0804) _______	(C0819) _______	(C0834) _______	(C0849) _______	(C0864) _______
Bulls, 1 year and over	(C0805) _______	(C0820) _______	(C0835) _______	(C0850) _______	(C0865) _______
PIGS:					
Boars	(C0806) _______	(C0821) _______	(C0836) _______	(C0851) _______	(C0866) _______
Sows and gilts for breeding	(C0807) _______	(C0822) _______	(C0837) _______	(C0852) _______	(C0867) _______
Nursing and weaner pigs	(C0808) _______	(C0823) _______	(C0838) _______	(C0853) _______	(C0868) _______
Grower and finishing pigs	(C0809) _______	(C0824) _______	(C0839) _______	(C0854) _______	(C0869) _______
POULTRY:					
Broilers, roasters and Cornish	(C0810) _______	(C0825) _______	(C0840) _______	(C0855) _______	(C0870) _______
Pullets under 19 weeks, intended for laying	(C0811) _______	(C0826) _______	(C0841) _______	(C0856) _______	(C0871) _______
Laying hens, 19 weeks and over	(C0812) _______	(C0827) _______	(C0842) _______	(C0857) _______	(C0872) _______
Turkeys	(C0813) _______	(C0828) _______	(C0843) _______	(C0858) _______	(C0873) _______

OTHER LIVESTOCK OR POULTRY: *(horses, ponies, mink, fox, goats, wild boar, geese, ducks, roosters, ostriches, emus, etc.)*

	Building 1	Building 2	Building 3	Building 4	Building 5
______________________________	(C0814) _______	(C0829) _______	(C0844) _______	(C0859) _______	(C0874) _______
______________________________	(C0815) _______	(C0830) _______	(C0845) _______	(C0860) _______	(C0875) _______

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9. In 2006, how was air quality controlled in each livestock building?

(Check all that apply)

	Building 1	Building 2	Building 3	Building 4	Building 5
Forced ventilation with filter on exhaust fans	☐ (C0901)	☐ (C0906)	☐ (C0911)	☐ (C0916)	☐ (C0921)
Forced ventilation, no filter	☐ (C0902)	☐ (C0907)	☐ (C0912)	☐ (C0917)	☐ (C0922)
Passive/natural ventilation (side curtains, or vent panels)	☐ (C0903)	☐ (C0908)	☐ (C0913)	☐ (C0918)	☐ (C0923)
Don't know	☐	☐	☐	☐	☐
Other, specify: (C0905/10/15/20/25) ________	☐ (C0904)	☐ (C0909)	☐ (C0914)	☐ (C0919)	☐ (C0924)

10. If forced ventilation was used (question 9), how was the ventilation rate controlled?

	Building 1	Building 2	Building 3	Building 4	Building 5
	(C1001)	(C1003)	(C1005)	(C1007)	(C1009)
With fans switched automatically (with thermostat/computer)	○ 01	○ 01	○ 01	○ 01	○ 01
With fans switched manually	○ 02	○ 02	○ 02	○ 02	○ 02
Other, specify: (C1002/04/06/08/10) ________	○ 03	○ 03	○ 03	○ 03	○ 03
Don't know	○ 99	○ 99	○ 99	○ 99	○ 99
Not applicable, no forced ventilation	○ 04	○ 04	○ 04	○ 04	○ 04

11. If forced ventilation with filter on exhaust fan was used (question 9), what is the frequency of filter change?

	Building 1	Building 2	Building 3	Building 4	Building 5
	(C1101)	(C1102)	(C1103)	(C1104)	(C1105)
Every month	○ 01	○ 01	○ 01	○ 01	○ 01
Every 2 to 5 months	○ 02	○ 02	○ 02	○ 02	○ 02
Every 6 to 11 months	○ 03	○ 03	○ 03	○ 03	○ 03
Every year	○ 04	○ 04	○ 04	○ 04	○ 04
Less frequently than every year	○ 05	○ 05	○ 05	○ 05	○ 05
Don't know	○ 99	○ 99	○ 99	○ 99	○ 99
Not applicable, no forced ventilation	○ 06	○ 06	○ 06	○ 06	○ 06

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Section II A - Liquid and/or Semi-solid Manure

12. In 2006, were there any liquid and/or semi-solid manure storage systems used on your operation? (C1201)
(semi-solid or "pumpable" manure)

Yes ◯ 01 No ◯ 03 (Go to question 24)

13. In 2006, how many liquid and/or semi-solid manure storage systems were on your operation?
(Include earthen manure storage, lagoon, open or covered tank, tank or pit below slatted floor, etc.)

(C1301) ______ number of storage systems

	Storage 1	Storage 2	Storage 3	Storage 4	Storage 5
14. What was the type of each liquid and/or semi-solid manure storage system?	(C1401)	(C1403)	(C1405)	(C1407)	(C1409)
15. What was the size (<u>surface</u> area or <u>diameter</u> or <u>volume</u>) of each liquid and/or semi-solid manure storage system? SURFACE	(C1501) 01 ◯ Square Feet 02 ◯ Square Metres (C1503)	(C1505) 01 ◯ Square Feet 02 ◯ Square Metres (C1507)	(C1509) 01 ◯ Square Feet 02 ◯ Square Metres (C1511)	(C1513) 01 ◯ Square Feet 02 ◯ Square Metres (C1515)	(C1517) 01 ◯ Square Feet 02 ◯ Square Metres (C1519)
OR	Length X Width (C1501) (C1502) 04 ◯ Feet 05 ◯ Metres 06 ◯ Yards (C1503)	Length X Width (C1505) (C1506) 04 ◯ Feet 05 ◯ Metres 06 ◯ Yards (C1507)	Length X Width (C1509) (C1510) 04 ◯ Feet 05 ◯ Metres 06 ◯ Yards (C1511)	Length X Width (C1513) (C1514) 04 ◯ Feet 05 ◯ Metres 06 ◯ Yards (C1515)	Length X Width (C1517) (C1518) 04 ◯ Feet 05 ◯ Metres 06 ◯ Yards (C1519)
OR DIAMETER	04 ◯ Feet 05 ◯ Metres 06 ◯ Yards (C1503)	04 ◯ Feet 05 ◯ Metres 06 ◯ Yards (C1507)	04 ◯ Feet 05 ◯ Metres 06 ◯ Yards (C1511)	04 ◯ Feet 05 ◯ Metres 06 ◯ Yards (C1515)	04 ◯ Feet 05 ◯ Metres 06 ◯ Yards (C1519)
OR VOLUME	07 ◯ Imperial gallons 09 ◯ Litres 10 ◯ Other, specify: (C1504) _________	07 ◯ Imperial gallons 09 ◯ Litres 10 ◯ Other, specify: (C1508) _________	07 ◯ Imperial gallons 09 ◯ Litres 10 ◯ Other, specify: (C1512) _________	07 ◯ Imperial gallons 09 ◯ Litres 10 ◯ Other, specify: (C1516) _________	07 ◯ Imperial gallons 09 ◯ Litres 10 ◯ Other, specify: (C1520) _________
16. What was the depth (deepest part) of each liquid and/or semi-solid manure storage system?	(C1601) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards (C1602)	(C1603) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards (C1604)	(C1605) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards (C1606)	(C1607) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards (C1608)	(C1609) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards (C1610)

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	Storage 1	Storage 2	Storage 3	Storage 4	Storage 5
17. What was the storage capacity of each liquid and/or semi-solid manure storge system?	(C1701) ____________ 01 ◯ Days 02 ◯ Months (C1702)	(C1703) ____________ 01 ◯ Days 02 ◯ Months (C1704)	(C1705) ____________ 01 ◯ Days 02 ◯ Months (C1706)	(C1707) ____________ 01 ◯ Days 02 ◯ Months (C1708)	(C1709) ____________ 01 ◯ Days 02 ◯ Months (C1710)
18. Was there a cover over the storage system? *(Include crust, straw, lid, tarp)*	(C1801) 01 ◯ Yes 03 ◯ No 99 ◯ Don't know	(C1808) 01 ◯ Yes 03 ◯ No 99 ◯ Don't know	(C1815) 01 ◯ Yes 03 ◯ No 99 ◯ Don't know	(C1822) 01 ◯ Yes 03 ◯ No 99 ◯ Don't know	(C1829) 01 ◯ Yes 03 ◯ No 99 ◯ Don't know
If yes, specify covering material	(C1802-06) ____________ (C1807)	(C1809-13) ____________ (C1814)	(C1816-20) ____________ (C1821)	(C1823-27) ____________ (C1828)	(C1830-34) ____________ (C1835)
19. What was the material used for the floor or floor lining of the liquid and/or semi-solid storage system?	(C1901-02) ____________ 99 ◯ Don't know	(C1903-04) ____________ 99 ◯ Don't know	(C1905-06) ____________ 99 ◯ Don't know	(C1907-08) ____________ 99 ◯ Don't know	(C1909-10) ____________ 99 ◯ Don't know
20. What was the material used for the walls of the storage system?	(C2001-02) ____________ 99 ◯ Don't know	(C2003-04) ____________ 99 ◯ Don't know	(C2005-06) ____________ 99 ◯ Don't know	(C2007-08) ____________ 99 ◯ Don't know	(C2009-10) ____________ 99 ◯ Don't know
21. For each liquid and/or semi-solid manure storage system, what was the <u>normal distance</u> to the nearest water source?	(C2101-03)	(C2108-10)	(C2115-17)	(C2122-24)	(C2129-31)
Normal distance to <u>nearest well</u>	(C2104) [ ] (C2105) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C2111) [ ] (C2112) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C2118) [ ] (C2119) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C2125) [ ] (C2126) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C2132) [ ] (C2133) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable
Normal distance to <u>nearest surface water</u> *(Surface water includes dugout, reservoir, pond, stream, creek, river, lake, wetland, ditches, marsh or slough)*	(C2106) [ ] (C2107) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C2113) [ ] (C2114) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C2120) [ ] (C2121) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C2127) [ ] (C2128) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C2134) [ ] (C2135) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable

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22. **Which of the following treatments were used for the liquid and/or semi-solid manure stored on your operation in 2006?**

Was liquid and/or semi-solid stored manure…?

(Check all that apply)

(C2201) ☐ aerated or agitated
(C2202) ☐ filtered through a marsh (constructed wetland)
(C2203) ☐ digested in an anaerobic system
(C2204) ☐ mixed with additives to modify odour, pH or nutrient retention
(C2205) ☐ mixed or turned to accelerate composting
(C2206) ☐ processed to separate liquid from solid
(C2207) ☐ dried
(C2208) ☐ Other, specify: (C2210) ____________________
(C2209) ☐ None

23. **What became of the liquid and/or semi-solid manure that was stored on your operation in 2006?**

Was liquid and/or semi-solid manure…?

(Check all that apply)

(C2301) ☐ spread on the land you operated (by you, an employee or someone else)
(C2302) ☐ sold or given to others
(C2303) ☐ removed by contractor
(C2304) ☐ Other, specify: (C2306) ____________________
(C2305) ☐ None

Section II B - Solid Manure

24. **In 2006, did you store solid manure on your agricultural operation?**
(Include solid manure piles on the ground or packs in barns, pens, corrals, feeding sites)

Yes ○ (Go to question 25)

No ○ (Go to question 35)

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	Pile(s) on the ground near livestock building(s)	Pile(s) on the ground near land application site(s)	Manure packs in barns, pens, corrals, feeding sites
25. Were any of the following types of solid manure storage system used in 2006?	(C2501) 01 ◯ Yes 03 ◯ No	(C2502) 01 ◯ Yes 03 ◯ No	(C2503) (C2504-05) 01 ◯ Yes 03 ◯ No
26. For each solid manure storage system, was manure stored on an impermeable pad?	(C2601) 01 ◯ Yes for all 02 ◯ Yes for some 03 ◯ No 99 ◯ Don't know	(C2602) 01 ◯ Yes for all 02 ◯ Yes for some 03 ◯ No 99 ◯ Don't know	(C2603) 01 ◯ Yes for all 02 ◯ Yes for some 03 ◯ No 99 ◯ Don't know
27. For each solid manure storage system, does the system have run-off containment?	(C2701) 01 ◯ Yes for all 02 ◯ Yes for some 03 ◯ No 99 ◯ Don't know	(C2702) 01 ◯ Yes for all 02 ◯ Yes for some 03 ◯ No 99 ◯ Don't know	(C2703) 01 ◯ Yes for all 02 ◯ Yes for some 03 ◯ No 99 ◯ Don't know
28. For each solid manure storage system, was there a roof or cover?	(C2801) 01 ◯ Yes for all 02 ◯ Yes for some 03 ◯ No 99 ◯ Don't know	(C2802) 01 ◯ Yes for all 02 ◯ Yes for some 03 ◯ No 99 ◯ Don't know	(C2803) 01 ◯ Yes for all 02 ◯ Yes for some 03 ◯ No 99 ◯ Don't know
29. If yes, what was the covering material?	(C2901-05)____________________	(C2906-10)____________________	(C2911-15)____________________
30. How long is solid manure collected over the winter usually stored? *(December to March)*	(C3001) 01 ◯ Less than 1 month 02 ◯ 1 month to less than 6 months 03 ◯ 6 months to less than 12 months 04 ◯ 12 months and longer 05 ◯ Not stored over winter	(C3002) 01 ◯ Less than 1 month 02 ◯ 1 month to less than 6 months 03 ◯ 6 months to less than 12 months 04 ◯ 12 months and longer 05 ◯ Not stored over winter	(C3003) 01 ◯ Less than 1 month 02 ◯ 1 month to less than 6 months 03 ◯ 6 months to less than 12 months 04 ◯ 12 months and longer 05 ◯ Not stored over winter
31. How long is solid manure collected over spring to fall usually stored? *(April to November)*	(C3101) 01 ◯ Less than 1 month 02 ◯ 1 month to less than 6 months 03 ◯ 6 months to less than 12 months 04 ◯ 12 months and longer 05 ◯ Not stored over spring to fall	(C3102) 01 ◯ Less than 1 month 02 ◯ 1 month to less than 6 months 03 ◯ 6 months to less than 12 months 04 ◯ 12 months and longer 05 ◯ Not stored over spring to fall	(C3103) 01 ◯ Less than 1 month 02 ◯ 1 month to less than 6 months 03 ◯ 6 months to less than 12 months 04 ◯ 12 months and longer 05 ◯ Not stored over spring to fall

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32. What is the distance that is normally maintained or the normal distance of the solid manure stored to the nearest water source?

	(C3201-03) **MINIMUM DISTANCE MAINTAINED from pile(s) on the ground near livestock building(s)**	(C3208-10) **MINIMUM DISTANCE MAINTAINED from pile (s) on the ground near land application site(s)**	(C3215-17) **NORMAL DISTANCE from manure packs in barns, pens, corrals, feeding sites**
Distance to nearest well	(C3204) ____________________	(C3211) ____________________	(C3218) ____________________
	(C3205) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C3212) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C3219) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable
Distance to nearest surface water *(Surface water includes dugout, reservoir, pond, stream, creek, river, lake, wetland, ditches, marsh or slough)*	(C3206) ____________________	(C3213) ____________________	(C3220) ____________________
	(C3207) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C3214) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable	(C3221) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Not applicable

33. Which of the following treatments were used for the solid manure stored on your operation in 2006?

Was solid manure…?

(Check all that apply)

(C3301) ☐ mixed with additives to modify odour, pH or nutrient retention

(C3302) ☐ mixed or turned to accelerate composting

(C3303) ☐ Other, specify: (C3305) ____

(C3304) ☐ None

34. What became of the solid manure that was stored on your operation in 2006?

Was solid manure…?

(Check all that apply)

(C3401) ☐ spread on the land you operated (by you, an employee or someone else)

(C3402) ☐ sold or given to others

(C3403) ☐ removed by contractor

(C3404) ☐ Other, specify: (C3406) ____

(C3405) ☐ None

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Section III - Grazing Livestock Management

35. In 2006, were there any grazing livestock on your operation? (C3501)

Yes ◯ 01 No ◯ 03

(Go to question 46)

36. How many of each type of livestock were grazed during the 2006 grazing season on your operation?

		Number	
Cattle and calves	Calves, under 1 year old	_______________	(C3601)
	Steers, 1 year and over	_______________	(C3602)
	Heifers, 1 year and over	_______________	(C3603)
	Cows	_______________	(C3604)
	Bulls, 1 year and over	_______________	(C3605)
Other livestock or poultry	specify: ___________________________	_______________	(C3606)
	___________________________	_______________	(C3607)

37. Do you practice rotational grazing (i.e. regularly moving livestock to different pastures or grazing paddocks throughout the grazing season)? *(Only consider actively managed rotational grazing)* (C3701)

Yes ◯ 01 No ◯ 03

For the next questions, consider the following two types of pasture:	**Tame or seeded pasture**	**Natural land for pasture**
38. In 2006, what area of each type of pasture was used for grazing on your operation? (C3801-03) *(Specify the unit of measure used)*	(C3804) (C3805)	(C3806) (C3807)
	01 ◯ Acres 02 ◯ Hectares	03 ◯ Arpents
39. In 2006, on average, for how many days was each type of pasture grazed on your operation? *(If different for different fields, give the average)*	(C3901)	(C3902)
40. What was the grass or forage height on each type of pasture when livestock were finished grazing the area in 2006? *(Specify the unit of measure used)*	(C4001) (C4002)	(C4003) (C4004)
	01 ◯ Inches 02 ◯ Centimetres	99 ◯ Don't know

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41. If tame or seeded pasture areas were on your operation, at what time interval were they re-seeded? (C4101)

(If time interval varies for different fields, give the average)

- Every 1 to 2 years 01 ◯
- Every 3 to 5 years 02 ◯
- Every 6 to 10 years 03 ◯
- Every 11 to 15 years 04 ◯
- Every 16 years or more 05 ◯
- Never re-seeded 06 ◯
- Don't know 99 ◯

42. In 2006, were any of the following practices used to extend the grazing season?

(Check all that apply)

(C4201) ☐ Using forages that grow in early spring
(C4202) ☐ Using forages that grow in late fall
(C4203) ☐ Supplementing grazing areas with additional hay
(C4204) ☐ Grazing swathed or cut/windrowed crops during winter
(C4205) ☐ Grazing standing vegetation or annual crop residues during winter
(C4206) ☐ Other, specify:(C4208) ______________________________
(C4207) ☐ None
☐ Don't know

43. In 2006, were any of the following practices used when feeding livestock in an open feeding area?

(Exclude corrals and feedlots)

(Check all that apply)

(C4301) ☐ Livestock are not fed in an open feeding area
(C4302) ☐ Move feeding sites to different locations
(C4303) ☐ Move watering sites to different locations
(C4304) ☐ Move sheltering / bedding sites to different locations
(C4305) ☐ Livestock are usually in the same part of the open feeding area
(C4306) ☐ Other, specify: (C4308) ______________________________
(C4307) ☐ None
☐ Don't know

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44. In 2006, were any pastures or grazing paddocks adjacent to surface water on your operation? (C4401)

(Surface water includes dugout, reservoir, pond, stream, creek, river, lake, wetland, ditches, marsh or slough)

Yes ◯ 01

No ◯ 03
(Go to question 46)

45. In 2006, what type of access did grazing livestock have to surface water bodies? (C4501)

(Surface water includes dugout, reservoir, pond, stream, creek, river, lake, wetland, ditches, marsh or slough)

01 ◯ Unlimited year round access

02 ◯ Unlimited access for the entire grazing season

03 ◯ Unlimited access for the winter feeding season

04 ◯ Limited access →

05 ◯ No access →

If limited or no access, which of the following practices was used to restrict access?
(Check all that apply)

(C4502) ☐ Fencing shoreline

(C4503) ☐ Remote or offsite watering system to a trough

(C4504) ☐ Access ramps for direct watering

(C4505) ☐ Stream crossings

(C4506) ☐ Limited or controlled grazing in riparian areas or adjacent to surface water

(C4507) ☐ Other, specify: (C4508) ________________________

Section IV - Wildlife Damage

46. In the last 5 years, was there any damage or injury to the livestock on your operation by any of the following wildlife groups?

(Check all that apply)

(C4601) ☐ Bears

(C4603) ☐ Raccoons

(C4604) ☐ Birds

(C4602) ☐ Other predators (foxes, wolves, lynxes, coyotes, etc.)

(C4605) ☐ Other, specify: (C4607) ____

(C4606) ☐ No damage caused by wildlife on my operation

(Go to question 48)

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47. In the last 5 years, how many livestock or poultry were injured or killed by wildlife on your operation?

		Number injured		Number killed
Dairy Cattle	(C4701)	__________________	(C4707)	_________________
Beef Cattle	(C4702)	__________________	(C4708)	_________________
Hogs	(C4703)	__________________	(C4709)	_________________
Poultry	(C4704)	__________________	(C4710)	_________________
Other, specify: ____________________	(C4705)	__________________	(C4711)	_________________
____________________	(C4706)	__________________	(C4712)	_________________

48. In the last 5 years, were any of the following practices used to reduce the impact of wildlife damage or injury to the livestock on your operation?

(Check all that apply)

(C4801) ☐ Fencing to protect stored feed and livestock
(C4802) ☐ Scaring devices or repellent systems
(C4803) ☐ Shooting or trapping by yourself or others
(C4804) ☐ Night penning near barn
(C4805) ☐ Guardian animals
(C4806) ☐ Border cropping
(C4807) ☐ Netting
(C4808) ☐ Other, specify: (C4810) ____
(C4809) ☐ No practices used specifically to reduce the impact of wildlife damage

49. In the last 5 years, was there any damage to BUILDINGS/EQUIPMENT on your operation caused by wildlife? (C4901)

Yes ○ 01 No ○ 03
(Go to question 51)

50. If yes, what was the damage?

Specify: (C5001) ____

51. In the last 5 years, did your operation receive any payments for the following purposes?

(Check all that apply)

(C5101) ☐ Financial compensation for wildlife damage
(C5102) ☐ Financial compensation for conservation of wildlife habitats
(C5103) ☐ Payments for the purchase of land or for easement by wildlife conservation organizations
(C5104) ☐ Payments for land use/management agreement
(C5105) ☐ None of the above

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Section V - Land and Water Management Practices

52. In 2006, were any of the following practices used on the land you operated?

If yes, specify the area for each practice used.

Did you use… *(Check all that apply)*	**Area**	**Unit of measure**
(C5201) ☐ cover or companion crops (crop seeded within an existing row between solid seeded crop, or intercropped)	(C5202)	(C5203) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents
(C5204) ☐ winter cover or green manure crops seeded alone after previous crop harvest	(C5205)	(C5206) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents
(C5207) ☐ strip cropping	(C5208)	(C5209) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents
(C5210) ☐ contour or across the slope cropping	(C5211)	(C5212) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents
(C5213) ☐ terracing (large soil ridges constructed on the contour or across the slope)	(C5214)	(C5215) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents
(C5216) ☐ permanent perennial forages on erodible land	(C5217)	(C5218) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents
(C5219) ☐ straw mulching (spread straw on erodible land)	(C5220)	(C5221) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents
(C5222) ☐ farmstead shelterbelts/windbreaks	(C5223)	(C5224) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents
(C5225) ☐ field shelterbelts (trees, shrubs)	(C5226)	(C5227) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents
(C5228) ☐ land with surface or subsurface drainage (e.g. constructed surface water channels or tile drainage)	(C5229)	(C5230) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents
(C5231) ☐ Other, specify: (C5232) __________________________	(C5233)	(C5234) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents

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The following questions are about land use changes. (C5301-04)

Woodlands include woodlots, sugarbush, tree windbreaks, bushes, shelterbelts.

	Area	Unit de measure
53. In 2006, what was the total woodland area on your operation?	(C5305)	01 ○ Acres (C5306) 02 ○ Hectares 03 ○ Arpents
54. Over the last five years, how much land area was changed FROM woodland TO pasture or cultivated cropland?	(C5401)	01 ○ Acres (C5402) 02 ○ Hectares 03 ○ Arpents
55. Over the last five years, how much land area was changed FROM pasture or cultivated cropland TO woodland?	(C5501)	01 ○ Acres (C5502) 02 ○ Hectares 03 ○ Arpents
56. In 2006, how much land area was changed FROM cultivated cropland TO pasture?	(C5601)	01 ○ Acres (C5602) 02 ○ Hectares 03 ○ Arpents
57. In 2006, how much land area was changed FROM pasture (tame, seeded and natural) TO cultivated cropland?	(C5701)	01 ○ Acres (C5702) 02 ○ Hectares 03 ○ Arpents

Wetlands

Different types of wetlands *may be distinguished by the amount of time they normally contain surface water and by the different plant communities they harbour. Temporary wetlands usually contain water only for a short time in the spring or after heavy precipitation.*

Seasonal wetlands *normally have water present until mid summer or early fall, and during most years. Examples include ponds, sloughs, potholes, seasonally flooded meadows, marshes and treed wet swamps.*

Permanent wetlands *are flooded year round except for extreme drought periods.*

Riparian buffer area *includes both permanent planted or natural vegetation adjacent to a seasonal or permanent wetland or waterway, extending upslope from the normal shoreline.*

Setback distance *is the distance between the normal shoreline of a seasonal or permanent wetland or waterway, extending upslope to the edge of manure, fertilizer or pesticide applications.*

58. Were there any seasonal wetlands on or adjacent to the land you operated in 2006? (C5801)

Yes ○ 01

No ○ 03 (Go to question 65)

Don't know ○ 99 (Go to question 65)

59. If yes, what was the total area of the seasonal wetlands?

(C5901) ____________________ (C5902) 01 ○ Acres 02 ○ Hectares 03 ○ Arpents

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60. Did you maintain a riparian buffer area around the seasonal wetlands? (C6001)

Yes ◯ 01

No ◯ 03

(Go to question 62)

61. If yes, how wide was it? (If it varied for different wetlands, give the average width)

(C6101) ______________________ (C6102) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards

62. Did you maintain a setback distance around the seasonal wetlands? (C6201)

Yes ◯ 01

No ◯ 03

(Go to question 64)

63. If yes, how wide was it? (If it varied for different wetlands, give the average width)

(C6301) ____________________ (C6302) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards

64. Did you stabilize shorelines or banks to prevent erosion? (C6401)

Yes ◯ 01

No ◯ 03

65. Were there any permanent wetlands on or adjacent to the land you operated in 2006? (C6501)

Yes ◯ 01

No ◯ 03

(Go to question 72)

Don't know ◯ 99

(Go to question 72)

66. If yes, what was the total area of the permanent wetlands?

(C6601) ___________________ (C6602) 01 ◯ Acres 02 ◯ Hectares 03 ◯ Arpents

67. Did you maintain a riparian buffer area around the permanent wetlands? (C6701)

Yes ◯ 01

No ◯ 03

(Go to question 69)

68. If yes, how wide was it? (If it varied for different wetlands, give the average width)

(C6801) __________________ (C6802) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards

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69. Did you maintain a setback distance around the <u>permanent</u> wetlands?

Yes ◯ No ◯
(Go to question 71)

70. If yes, how wide was it? (If it varied for different wetlands, give the average width)

________________________ ◯ Feet ◯ Metres ◯ Yards

71. Did you stabilize shorelines or banks to prevent erosion?

Yes ◯ No ◯

(C6901)

01 03

(C7001) (C7002) 01 02 03

72. Were there any <u>waterways</u> on or adjacent to the land you operated in 2006? (C7201)

Yes ◯ 01 No ◯ 03 (C7101) Don't know ◯ 99

01 (Go to question 79) (Go to question 79)

Waterw **73. If yes, what was the total length of the <u>waterways</u>?**

Waterw (C7301) _______________ (C7302) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards 04 ◯ Miles 05 ◯ Kilometres

74. Did you maintain a riparian buffer area around the <u>waterways</u>? (C7401)

Yes ◯ 01 No ◯ 03
(Go to question 76)

75. If yes, how wide was it? (If it varied for different waterways, give the average width)

(C7501) _______________ (C7502) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards

76. Did you maintain a setback distance from the <u>waterways</u>? (C7601)

Yes ◯ 01 No ◯ 03
(Go to question 78)

77. If yes, how wide was it? (If it varied for different waterways, give the average width)

(C7701) _______________ (C7702) 01 ◯ Feet 02 ◯ Metres 03 ◯ Yards

78. Did you stabilize shorelines or banks to prevent erosion? (C7801)

Yes ◯ 01 No ◯ 03

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Domestic Water

79. In 2006, were there any active water wells on the land you operated? (C7901)

Yes ○ 01

No ○ 03 (Go to question 81)

Don't know ○ 99 (Go to question 81)

80. If yes, how often is the water tested to meet quality standards for human and/or livestock consumption? (C8001)

(If different for different wells, give the average)

01 ○ At least once a year

02 ○ Every 2 years

03 ○ Every 3 to 5 years

04 ○ Every 6 years or more

05 ○ Not tested/not a concern

06 ○ Never

99 ○ Don't know

81. In 2006, were there any abandoned water wells on the land you operated? (C8101)

Yes ○ 01

No ○ 03 (Go to question 83)

Don't know ○ 99 (Go to question 83)

82. If yes, have these abandoned wells been decommissioned? (C8201)

(wells filled in, capped)

01 ○ All decommissioned

02 ○ Some decommissioned

03 ○ None

99 ○ Don't know

5-5100-503.1

Section VI - Waste Management and Hazardous Materials

83. In 2006, how were the following materials stored on your farm operation? (C8301-08)

(Check all that apply)	Commercial Fertilizers	Pesticides *(insecticides, herbicides, fungicides)*	Petroleum Products: Fuel	Petroleum Products: Oil and Grease
Building **with** a concrete floor or pad	☐ (C8309)	☐ (C8315)	☐ (C8321)	☐ (C8327)
Building **without** a concrete floor or pad	☐ (C8310)	☐ (C8316)	☐ (C8322)	☐ (C8328)
Above ground sealed tank	☐ (C8311)	☐ (C8317)	☐ (C8323)	☐ (C8329)
Other, specify:______________________ (C8314/20/26/32)	☐ (C8312)	☐ (C8318)	☐ (C8324)	☐ (C8330)
Not stored on the farm operation	☐ (C8313)	☐ (C8319)	☐ (C8325)	☐ (C8331)

	Commercial Fertilizers (C8401)	Pesticides *(insecticides, herbicides, fungicides)* (C8402)	Petroleum Products: Fuel (C8403)	Petroleum Products: Oil and Grease (C8404)
84. Did the storage site have a containment system to handle spills?	01 ○ Yes 03 ○ No 02 ○ N/A	01 ○ Yes 03 ○ No 02 ○ N/A	01 ○ Yes 03 ○ No 02 ○ N/A	01 ○ Yes 03 ○ No 02 ○ N/A

85. In 2006, how were these products (including their containers) disposed of? Were they disposed of …

(Check all that apply)	Commercial Fertilizers	Pesticides *(insecticides, herbicides, fungicides)*	Petroleum Products *(oil, grease)*	Other Hazardous Materials *(batteries, paint)*
… on farm (incineration, buried, etc.)	☐ (C8501)	☐ (C8509)	☐ (C8517)	☐ (C8525)
… with domestic garbage	☐ (C8502)	☐ (C8510)	☐ (C8518)	☐ (C8526)
… in a municipal recycling program	☐ (C8503)	☐ (C8511)	☐ (C8519)	☐ (C8527)
… by returning to supplier	☐ (C8504)	☐ (C8512)	☐ (C8520)	☐ (C8528)
… using waste disposal sites for hazardous waste or dangerous goods	☐ (C8505)	☐ (C8513)	☐ (C8521)	☐ (C8529)
Other, specify : ______________________ (C8508/16/24/32)	☐ (C8506)	☐ (C8514)	☐ (C8522)	☐ (C8530)
No disposal	☐ (C8507)	☐ (C8515)	☐ (C8523)	☐ (C8531)

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Wastewater *includes water to wash produce, milkhouse, pens or facilities, silage leakage, run-off water from livestock pens, etc.*

86. In 2006, how was wastewater managed on your operation?
Was it…

(Check all that apply)

(C8601) ☐ discharged to a constructed retention pond or holding pond

(C8602) ☐ discharged to a septic or sewer system

(C8603) ☐ discharged into a filtration marsh or wetland

(C8604) ☐ included in the liquid manure system

(C8605) ☐ collected in holding or storage tank

(C8606) ☐ Other, specify: (C8608) ______________________________

(C8607) ☐ Not actively managed/wastewater removed through natural drainage

87. In 2006, how many livestock or poultry were disposed of using each of the following method?

On farm:	**Dairy cattle**	**Beef cattle**	**Hogs**	**Poultry**
Buried	________(C8701)	________(C8707)	________(C8713)	________(C8719)
Incinerated	________(C8702)	________(C8708)	________(C8714)	________(C8720)
Composted	________(C8703)	________(C8709)	________(C8715)	________(C8721)
Other, specify: ____________ (C8705/11/17/23/30)	________(C8704)	________(C8710)	________(C8716)	________(C8722)
Off farm collection service (e.g. rendering enterprise)	________(C8706)	________(C8712)	________(C8718)	________(C8724)

On farm:	**Other livestock or poultry** specify:	Number
Buried	______________	____________(C8725/C8731)
Incinerated	______________	____________(C8726/C8732)
Composted	______________	____________(C8727/C8733)
Other, specify: ____________ (C8705/11/17/23/30)	______________	____________(C8728/C8734)
Off farm collection service (e.g. rendering enterprise)	______________	____________(C8730/C8736)

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Section VII - Environmental Farm Plan

88. Does your farm operation have a formal, written Environmental Farm Plan (EFP) as part of a federal, provincial or industry program?

(C8801)

A formal, written farm environmental farm plan is an overall assessment of environmental issues or concerns related to your operation, and can include individual and/or group planning processes.

Yes, plan is developed ◯ 01 ↓

Yes, plan is in development or being reviewed ◯ 02 ↓

No ◯ 03 ↓ (Go to question 93)

89. When was this Environmental Farm Plan (EFP) developed or last updated? (C8901)

01 ◯ Less than 1 year ago

02 ◯ From 1 to 3 years ago

03 ◯ From 3 to 5 years ago

04 ◯ More than 5 years ago

90. To what extent were the Beneficial Management Practices (BMPs) identified in the action plan of your EFP implemented on your operation? (C9001)

01 ◯ Practices fully implemented

02 ◯ Practices partially implemented

03 ◯ Practices not implemented

91. Was any <u>technical</u> assistance received from any of the following groups to help implement the Beneficial Management Practices (BMPs) identified in the action plan of your EFP?

(Check all that apply)

(C9101) ☐ Did not receive assistance

(C9102) ☐ Government agency

(C9103) ☐ Industry (input supplier, processors, etc.)

(C9104) ☐ Environmental non-governmental organizations

(C9105) ☐ Producer association

(C9106) ☐ College/University

(C9107) ☐ EFP planning advisor / facilitator

(C9108) ☐ Agrologist

(C9109) ☐ Other, specify : (C9110) ____

92. Was any financial assistance (from any source) received to offset costs for implementation of Beneficial Management Practices (BMPs) identified in the action plan of your EFP? (C9201)

(Exclude drought payments)

Yes ○ 01 No ○ 03

93. In 2006, were global positioning system (GPS) equipment or products (digital maps) used on your operation? (C9301)

Yes ○ 01

No ○ 03 (Go to question 95)

Don't know ○ 99 (Go to question 95)

94. If yes, were they used …

(Check all that apply)

(C9401) ☐ to collect information for soil and crop management

(C9402) ☐ to collect information for water management

(C9403) ☐ as a tracking or guidance system on tractor to eliminate overlaps and misses in field operations

(C9404) ☐ to target or vary fertilizer or manure application rate

(C9405) ☐ to target or vary pesticide application rates

(C9406) ☐ Other, specify: (C9407) ___________________________________

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Section VI - Data sharing agreement

Thank you for taking the time to participate in our survey. To reduce response burden and to ensure more uniform statistics, Statistics Canada has entered into an agreement under section 12 of the Statistics Act with Agriculture and Agri-Food Canada, and the ministry/department of agriculture of the provinces of Québec, Ontario and Alberta, for the sharing of information from this survey. Also, for the Québec residents only, Statistics Canada has entered into an agreement under section 12 of the Statistics Act with the Institut de la statistique du Québec. Statistics Canada will not share your name, address or other identifying information. The information is required to be kept confidential and used only for statistical and research purposes.

95. Do you agree to share the information on this survey with Agriculture and Agri-Food Canada? (C9501)

Yes ○ 01 No ○ 03

96a. If you are a resident of Ontario or Alberta, do you agree to share the information on this survey with your provincial ministry/department of agriculture? (C9601)

Yes ○ 01 No ○ 03

96b. If you are a resident of Québec, do you agree to share the information on this survey with the Ministère de l'Agriculture, de l'Alimentation et des Pêcheries du Québec and the Institut de la statistique du Québec?

Yes ○ 01 No ○ 03

In order to extend the research capabilities of this survey, Statistics Canada intends to combine the information from this survey with the information your operation provided on the 2006 Census of Agriculture. Your operation's 2006 Census of Agriculture information will only be used by Statistics Canada and will not be shared.

97. Do you agree that Statistics Canada may combine the information from this survey with the information you provided on the 2006 Census of Agriculture? (C9701)

Yes ○ 01 No ○ 03

Comments:

Thank you for your cooperation.

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APPENDIX 2: MODIFICATIONS TO THE DATA IN ORDER TO CALCULATE THE BMP ADOPTION INDEX

The following is a list of modifications made to the FEMS 2006 data set for it to be used to calculate the BMP Adoption Index:

Filter questions

- Filter questions were used in FEMS. If a respondent answered no to a filter question, each of the questions related to the filter question were excluded from their total score. In the crop file, Q11, 15, 18, 27, 36, 38, 40, 54, 61, 68, 75 and 77 are filter question. In the livestock file Q4, 6, 12, 24, 35, 58, 65, 72, 79, 81 were filter questions.

Crop file Q6: **Tillage Practices**

- The survey data was gathered such that the producer indicated how many acres were under each of conventional till, conservation till or no till/zero till. In many cases a producer uses more than one type of tillage on their farm. Each tillage option was converted to a percentage of crop area by dividing each option by the total number of acres. This value was multiplied by the weighting in the PI table.

- Respondents with the following crop types were excluded since they do not practice tillage regularly, or do not have tillage options due to the crop grown: Fruit and tree nut farms, potato farms, and producers with 100% hay or alfalfa (these were excluded since they are perennial crops and not regularly tilled).

- On farms where several crop types are grown and include the above, the farm was excluded from this variable if one or more of potato, alfalfa, hay, apples or blueberries made up 50% of the crop area. For those farms where one of these crops made up less than 50%, their score will be based on whatever tillage practices is used for the crops on the larger 50% of the farmland.

Crop file Q7: **Crop Rotations**

- The survey data was collected so that the respondent identified the crop harvested in 2006 and the crop harvested the year previous instead of directly asking if crop rotations were practiced. If more than 50% of the farm land had a different crop grown on it the previous year it was assumed that the farmer is making an attempt to manage in a sustainable way and was given a score for crop rotations.
- The quality or effectiveness of the crop rotations were not assessed.
- Some perennial crops such as hay and alfalfa are not rotated regularly, nor are orchard crops such as apples and blueberries. These crops were excluded from the assessment and given an n/a score.

Crop file Q8: **Crop residues**

- The data were gathered so that respondents indicated the treatment of their residues for each of the crops grown on their farm in 2006. The respondent could include as many treatments as they used, therefore multiple responses are possible. The data set was modified to indicate that a residue treatment was practiced if it was used on any crop grown.
- Crops that do not produce residues include fodder corn, alfalfa, hay, apples and low bush blueberries, therefore farms that grew these crops were excluded.

Crop file: Section II – **Pesticide application practices**

- Producers are asked about applying herbicides, insecticides and fungicides in Q36, 38 and 40, respectively. The variables were combined so that if a producer responded yes to any of the options, it was indicated that they applied pesticides. Similarly, a ‘do not use pesticides’ variable was created from the producers who responded ‘no’ for all three pesticide types.

Crop file: Q42: **considerations for applying pesticides**

- If a producer responded to any of the options for any of the three types of pesticides it was included in the final score.

Crop file: Q44: **pesticide sprayer calibration**

- where a respondent has indicated that pesticides have been sprayed by a custom operator in the other category, I assumed that the operator has calibrated the sprayer for that particular application, therefore have indicated that the sprayer was calibrated between applications.

Crop file: Q45, 46, 47: **controlling pesticide drift, reducing amount of pesticide, alternative methods to control weeds, insects, fungi.**

- The responses to these questions are all positive practices. After consulting with experts (T. MacDonald, L. Cass), it was determined that these practices all have relatively equal individual efficacy in improving environmental performance, however efficacy improves as more practices are implemented, therefore, ranking and/or comparing practices within these groupings is not appropriate. The scores were calculated for these three questions by counting the number of practices being implemented. A response of ‘did not use any of these methods’ was subtracted from the final score.

Livestock file: **Q6**: If producers responded no to this question, Q7-11 were excluded.

Livestock file: Q9: **Livestock housing ventilation**

- The survey data allowed respondents to provide information for up to 5 buildings. In some cases, different treatments were used for different buildings. The answers were combined so that there was only one response for the question, however it could mean there is more than one treatment being used.
- If producers indicated they used passive/natural ventilation, Q10, 11 were excluded.
- If producers responded that there was no forced ventilation, Q11 was excluded.

Livestock file: Section II**: Manure**

- The FEMS questionnaire asked about the type of liquid and semi-solid manure storage, and the location of solid manure storage. Options for liquid manure storage included an earthen manure storage/lagoon, a tank or a tank below slats. For solid manure the options were piles on ground near livestock buildings, piles on ground near application sites, or manure packs in pens, corrals, feeding sites. It was determined that each type is legitimate and can be part of a sustainable farm operation if managed correctly. Therefore, all storage types were assigned a ranking of 3 to indicate a neutral practice.
- All of the questions allow respondents to answer for multiple manure storages, however only one value could be included in the BMP adoption score calculation. Therefore, responses were combined where possible. In cases such as Q18 that asked whether the

manure was covered, where one manure storage was covered and another wasn’t, the practice on the largest manure storage was used.

Table 3: FEMS 2006 practices and rankings

	A	B	C	D	E	F	G	H
3			**Soil**					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
5	**Tillage practices**							
6	Conventional tillage	***1***	0	0	1	1	0	0
7	Conservation tillage	***4***	4	4	4	4	0	3
8	No till/zero till	***5***	5	5	5	5	0	4
9								
10	practice crop rotation	***5***	0	0	0	0	0	0
11	do not practice crop rotation	***1***	0	0	0	0	0	0
12								
13	**Crop residue management**							
14	crop residues left on ground	***4***	5	5	0	4	4	3
15	chop and spread crop residues	***5***	5	5	0	5	5	4
16	spread residues without chopping	***4***	4	4	0	4	4	4
17	bale residues	***3***	1	1	0	1	1	0
18	burn crop residues	***1***	1	1	0	1	1	0
19	incorporate crop residues into soil	***1***	1	1	2	4	3	0
20	compost residues into a pile	***3***	1	1	0	2	1	0
21	collect (chaff portion) residues	***4***	1	1	0	2	1	0
22	crop residues grazed by livestock	***3***	2	2	0	0	3	0
23								
24	**fertilizer application methods**							
25	fertilizer applied with seed	***5***	0	0	0	0	0	0
26	fertilizer applied by subsurface application separate from seeding (shovel, knife, bander)	***4***	0	0	0	0	0	0
27	fertilizer applied by subsurface application during seeding in separate band away from seed (includes mid-row banding)	***5***	0	0	0	0	0	0
28	fertilizer applied by post-plant or post emergent application (top/side dressing)	***4***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
29	fertilizer applied by surface broadcast and not incorporated	***2***	0	0	0	0	0	0
30	fertilizer applied by surface broadcast and incorporated	***3***	0	0	2	0	0	0
31	fertilizer applied by fertigation	***3***	0	3	0	0	0	0
32	fertilizer applied by foliar application	***3***	0	0	0	0	0	0
33								
34	**Soil testing practices**							
35	Soil testing every year	***5***	0	0	0	0	0	0
36	soil testing every 2-3 years	***4***	0	0	0	0	0	0
37	soil testing every 4-5 years	***3***	0	0	0	0	0	0
38	soil testing every 6 years or more	***2***	0	0	0	0	0	0
39	no soil testing	***1***	0	0	0	0	0	0
40								
41	**fertilizer application practices**							
42	quantity of fertilizer reduced due to manure application	***5***	0	0	0	0	0	0
43	quantity of fertilizer not reduced due to manure application	***1***	0	0	0	0	0	0
44								
45	fertilizer applied before seeding, or before new growth begins	***5***	0	0	0	0	0	0
46	fertilizer applied after seeding, before harvest or after new growth begins	***4***	0	0	0	0	0	0
47	fertilizer applied after harvest	***1***	0	0	0	0	0	0
48								
49	solid manure tested for nutrient content before application	***5***	0	0	0	0	0	0
50	solid manure not tested for nutreint content before application	***1***	0	0	0	0	0	0
51								
52	**Solid manure application timing**							
53	solid manure applied before crop growth	***5***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			**Soil**					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
54	solid manure applied after crop growth began	***4***	0	0	0	0	0	0
55	solid manure applied after harvest (before ground is frozen)	***2***	0	0	0	0	0	0
56	solid manure applied on frozen ground	***1***	0	0	0	0	0	0
57								
58	**Solid manure application methods**							
59	application of solid manure - broadcast and incorporated	***5***	0	0	2	4	0	0
60	application of solid manure - broadcast and not incorporated	***1***	0	0	0	0	0	0
61								
62	**Solid manure incorporation practices**							
63	solid manure incorporated same day as application	***5***	0	0	2	0	0	0
64	solid manure incorporated 1-2 days after application	***4***	0	0	2	0	0	0
65	solid manure incorporated 3-5 days after application	***3***	0	0	2	0	0	0
66	solid manure incorporated more than 5 days after application	***2***	0	0	2	0	0	0
67	solid manure was not incorporated after application	***1***	0	0	0	0	0	0
68								
69	liquid or semi-solid manure tested for nutrient content before application	***5***	0	0	0	0	0	0
70	liquid or semi-solid manure not tested for nutreint content before application	***1***	0	0	0	0	0	0
71								
72	**Liquid manure application timing**							
73	liquid or semi-solid manure applied before crop growth	***5***	0	0	0	0	0	0
74	liquid or semi-solid manure applied after crop growth began	***4***	0	0	0	0	0	0
75	liquid or semi-solid manure applied after harvest (before ground is frozen)	***2***	0	0	0	0	0	0
76	liquid or semi-solid manure applied on frozen ground	***1***	0	0	0	0	0	0
77								
78	**liquid manure application methods**							

	A	B	C	D	E	F	G	H
3			**Soil**					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
79	application of liquid or semi-solid manure - broadcast and incorporated into soil	***4***	0	0	2	4	0	0
80	application of liquid or semi-solid manure - broadcast and not incorporated	***1***	0	0	0	0	0	0
81	application of liquid or semi-solid manure - directly injected into the soil	***5***	0	0	0	4	0	0
82	application of liquid or semi-solid manure - applied below crop canopy or using low boom applicator	***4***	0	0	0	0	0	0
83	application of liquid or semi-solid manure - using irrigation system	***1***	0	2	0	0	0	0
84								
85	**Liquid manure incorporation timing**							
86	liquid or semi-solid manure incorporated same day as application	***5***	0	0	2	0	0	0
87	liquid or semi-solid manure incorporated 1-2 days after application	***4***	0	0	2	0	0	0
88	liquid or semi-solid manure incorporated 3-5 days after application	***3***	0	0	2	0	0	0
89	liquid or semi-solid manure incorporated more than 5 days after application	***2***	0	0	2	0	0	0
90								
91	**Pesticide application practices**							
92	formally certified pesticide applicator applied all pesticide applications	***5***	0	0	0	0	0	0
93	formally certified pesticide applicator applied some pesticide applications	***3***	0	0	0	0	0	0
94	formally certified pesticide applicator applied no pesticide applications	***2***	0	0	0	0	0	0
95								
96	pesticide sprayer calibrated when it breaks down	***2***	0	0	0	0	0	0
97	pesticide sprayer calibrated before the beginning of the crop season/before first application	***3***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
98	pesticide sprayer calibrated between applications of different types of pesticides	***5***	0	0	0	0	0	0
99	pesticide sprayer not calibrated	***1***	0	0	0	0	0	0
100								
101	**Pesticide drift management**							
102	controlled pesticide drift by applying pesticides only when winds are below recommended thresholds	***4***	0	0	0	0	0	0
103	controlled pesticide drift by using low drift or low pressure nozzles	***4***	0	0	0	0	0	0
104	controlled pesticide drift by using shrouded booms	***4***	0	0	0	0	0	0
105	controlled pesticide drift by adding anti-drift agents or chemicals	***4***	0	0	0	0	0	0
106	controlled pesticide drift by leaving untreated buffer zones	***4***	0	0	0	0	0	0
107	no specific method employed to control pesticide drift	***1***	0	0	0	0	0	0
108								
109	**Pesticide reduction practices**							
110	methods to reduce the amount of pesticides used - use tracking, guidance, or marking systems to minimize overlap and misses	***4***	0	0	0	0	0	0
111	methods to reduce the amount of pesticides used - spray only target infested areas	***4***	0	0	0	0	0	0
112	methods to reduce the amount of pesticides used - use in line injection/mixing systems to eliminate unused tank mixes	***4***	0	0	0	0	0	0
113	methods to reduce the amount of pesticides used - apply smaller amounts than rate recommended on chemical product label	***3***	0	0	0	0	0	0
114	no specific method used to reduce amount of pesticides used	***1***	0	0	0	0	0	0
115								
116	**Alternative pest management practices**							

	A	B	C	D	E	F	G	H
3			**Soil**					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
117	alternative methods to controlling weeds, insects or diseases - plant tolerant or resistant plants, varieties or cultivars	***5***	0	0	0	0	0	0
118	alternative methods to controlling weeds, insects or diseases - rotate crops to disrupt pest cycles	***5***	0	0	0	0	0	0
119	alternative methods to controlling weeds, insects or diseases - eliminate, remove or incorporate diseased plant, pruning residues or cull piles	***3***	3	0	2	0	0	0
120	alternative methods to controlling weeds, insects or diseases - plant green manure or cover crops	***5***	5	5	0	5	5	5
121	alternative methods to controlling weeds, insects or diseases - plant in the fall	***5***	5	5	0	5	5	5
122	alternative methods to controlling weeds, insects or diseases - use tillage implements	***3***	0	0	2	2	0	0
123	alternative methods to controlling weeds, insects or diseases - use hand weeding/hoeing	***5***	0	0	3	0	0	0
124	alternative methods to controlling weeds, insects or diseases - use covers or mulches	***5***	5	5	0	3	0	4
125	alternative methods to controlling weeds, insects or diseases - introduce natural enemies/biological control agents	***3***	0	0	0	0	0	0
126	alternative methods to controlling weeds, insects or diseases - lure or trap crops	***5***	0	0	0	0	0	0
127								
128	**land and water management practices**							
129	cover or companion crops seeded	***4***	5	5	0	5	5	5
130	winter cover or green manure crops seeded alone after previous crop harvest	***4***	5	5	0	5	5	5
131	strip cropping used	***4***	5	5	0	5	4	5
132	contour or across the slope cropping used	***4***	0	5	3	3	0	0
133	terracing used	***4***	0	5	0	3	0	0
134	permanent perennial forages planted on erodible land	***5***	5	5	0	5	5	5
135	straw mulching (spread straw) performed on erodible land	***4***	5	5	0	3	0	4

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
136	farmstead shelterbelts/windbreaks established	***5***	5	0	0	0	0	0
137	field shelterbelts (trees, shrubs) planted	***5***	5	0	0	0	0	0
138	land with surface or subsurface drainage (constructed surface water channels or tile drainage) present	***3***	0	3	0	0	3	0
139								
140	**surface water management**							
141	maintaining a riparian buffer along a seasonal wetland	***5***	0	0	0	0	5	0
142	did not maintain a riparian buffer along a seasonal wetland	***1***	0	0	0	0	1	0
143	maintaining a riparian buffer along a permanent wetland	***5***	0	0	0	0	5	0
144	did not maintain a riparian buffer along a permanent wetland	***1***	0	0	0	0	1	0
145	maintaining a riparian buffer along a waterway	***5***	0	0	0	0	5	0
146	did not maintain a riparian buffer along a waterway	***1***	0	0	0	0	1	0
147								
148	maintainging a setback distance around a seasonal wetland	***5***	0	0	0	0	5	0
149	did not maintain a setback distance around a seasonal wetland	***1***	0	0	0	0	0	0
150	maintainging a setback distance around a permanent wetland	***5***	0	0	0	0	5	0
151	did not maintain a setback distance around a permanent wetland	***1***	0	0	0	0	0	0
152	maintainging a setback distance around a waterway	***5***	0	0	0	0	5	0
153	did not maintain a setback distance around a waterway	***1***	0	0	0	0	0	0
154								
155	stabilizing shorelines or banks around a permanent wetland	***5***	0	0	0	0	0	0
156	did not stabilize shorelines or banks around a permanent wetland	***1***	0	0	0	0	0	0
157	stabilizing shorelines or banks around a seasonal wetland	***5***	0	0	0	0	0	0
158	did not stabilize shorelines or banks around a seasonal wetland	***1***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
159	stabilizing shorelines or banks along a waterway	***5***	0	0	0	0	0	0
160	did not stabilize shorelines or banks along a waterway	***1***	0	0	0	0	0	0
161								
162	**well water quality**							
163	test water quality in active wells at least once a year	***5***	0	0	0	0	0	0
164	test water quality in active wells every 2 years	***4***	0	0	0	0	0	0
165	test water quality in active wells every 3-5 years	***3***	0	0	0	0	0	0
166	test water quality in active wells every 6 years or more	***2***	0	0	0	0	0	0
167	never test water quality in active wells	***1***	0	0	0	0	0	0
168	water quality in active wells not tested, not a concern	***0***	0	0	0	0	0	0
169								
170	all abandoned water wells decommissioned	***5***	0	0	0	0	0	0
171	some abandoned water wells decommissioned	***3***	0	0	0	0	0	0
172	no abandoned water wells decommissioned	***1***	0	0	0	0	0	0
173								
174								
175	**Hazardous material storage and disposal management**							
176	Commercial fertilizer storage in a building with a concrete floor or pad	***5***	0	0	0	0	0	0
177	Commercial fertilizer storage in a building without a concrete floor or pad	***2***	0	0	0	0	0	0
178	Commercial fertilizer storage in an above ground sealed tank	***5***	0	0	0	0	0	0
179	Commercial fertilizer not stored on farm operation	***5***	0	0	0	0	0	0
180								
181	Pesticides stored in a building with a concrete floor or pad	***5***	0	0	0	0	0	0
182	Pesticides stored in a building without a concrete floor or pad	***2***	0	0	0	0	0	0
183	Pesticides stored in an above ground sealed tank	***5***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
184	Pesticides not stored on farm operation	***5***	0	0	0	0	0	0
185								
186	fuel storage in a building with a concrete floor or pad	***5***	0	0	0	0	0	0
187	fuel storage in a building without a concrete floor or pad	***2***	0	0	0	0	0	0
188	fuel storage in an above ground sealed tank	***5***	0	0	0	0	0	0
189	fuel not stored on farm operation	***5***	0	0	0	0	0	0
190								
191	oil and grease stored in a building with a concrete floor or pad	***5***	0	0	0	0	0	0
192	oil and grease stored in a building without a concrete floor or pad	***2***	0	0	0	0	0	0
193	oil and grease stored in an above ground sealed tank	***5***	0	0	0	0	0	0
194	oil and grease not stored on farm operation	***5***	0	0	0	0	0	0
195								
196	containment system to handle spills - commercial fertilizers	***5***	0	0	0	0	0	0
197	no containmnet system to handle spills - commercial fertilizers	***1***	0	0	0	0	0	0
198	containment system to handle spills - pesticides	***5***	0	0	0	0	0	0
199	no containmnet system to handle spills - pesticides	***1***	0	0	0	0	0	0
200	containment system to handle spills - fuel	***5***	0	0	0	0	0	0
201	no containmnet system to handle spills - fuel	***1***	0	0	0	0	0	0
202	containment system to handle spills - oil and grease	***5***	0	0	0	0	0	0
203	no containmnet system to handle spills - oil and grease	***1***	0	0	0	0	0	0
204								
205	Commercial fertilizer disposed on farm (incineration, burning, etc)	***1***	0	0	0	0	0	0
206	Commercial fertilizer disposed with domestic garbage	***1***	0	0	0	0	0	0
207	Commercial fertilizer disposed in a municipal recycling program	***5***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
208	Commercial fertilizer disposed by returning to supplier	***5***	0	0	0	0	0	0
209	Commercial fertilizer disposed using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0	0
210	no commercial fertilizer disposal	***5***	0	0	0	0	0	0
211								
212	pesticides disposed of on farm (incineration, burning, etc)	***1***	0	0	0	0	0	0
213	pesticides disposed of with domestic garbage	***1***	0	0	0	0	0	0
214	pesticides disposed of in a municipal recycling program	***5***	0	0	0	0	0	0
215	pesticides disposed of by returning to supplier	***5***	0	0	0	0	0	0
216	pesticides disposed of using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0	0
217	no disposal of pesticides	***5***	0	0	0	0	0	0
218								
219	petroleum products disposed of on farm (incineration, burning, etc)	***1***	0	0	0	0	0	0
220	petroleum products disposed of with domestic garbage	***1***	0	0	0	0	0	0
221	petroleum products disposed of in a municipal recycling program	***5***	0	0	0	0	0	0
222	petroleum products disposed of by returning to supplier	***5***	0	0	0	0	0	0
223	petroleum products disposed of using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0	0
224	no disposal of petroleum products	***5***	0	0	0	0	0	0
225								
226	other hazardous materials disposed of on farm (incineration, burning, etc)	***1***	0	0	0	0	0	0
227	other hazardous materials disposed of with domestic garbage	***1***	0	0	0	0	0	0
228	other hazardous materials disposed of in a municipal recycling program	***5***	0	0	0	0	0	0
229	other hazardous materials disposed of by returning to supplier	***5***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
230	other hazardous materials disposed of by using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0	0
231	no disposal of other hazardous materials	***5***	0	0	0	0	0	0
232								
233	**wastewater management**							
234	wastewater discharged to a septic or sewer system	***4***	0	0	0	0	0	0
235	wastewater discharged into a filtration marsh or wetland	***4***	0	0	0	0	0	0
236	wastewater included in the liquid manure system	***5***	0	0	0	0	0	0
237	wastewater collected in holding or storage tank	***5***	0	0	0	0	0	0
238	wastewater discharged to a constructed retention pond or holding pond	***4***	0	0	0	0	0	0
239	wastewater not actively managed	***1***	0	2	0	0	0	0
240								
241	**deadstock management**							
242	deadstock disposal - buried	***4***	0	0	0	0	0	0
243	deadstock disposal - incinerated	***3***	0	0	0	0	0	0
244	deadstock disposal - composted	***4***	0	0	0	0	0	0
245	deadstock disposal - off farm collection service	***5***	0	0	0	0	0	0
246								
247								
248	GPS used for collecting information for soil and crop management	***4***	0	0	0	0	0	0
249	GPS used for collecting information for water management	***4***	0	0	0	0	0	0
250	GPS used for as a tracking or guidance system on tractor to eliminate overlaps and misses on field	***5***	0	0	0	0	0	0
251	GPS used for targeting or varying fertilizer or manure application rate	***4***	0	0	0	0	0	0
252	GPS used for targeting or varying pesticide application rates	***4***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
253								
254	**livestock housing air quality**							
255	livestock building air quality managed by forced ventilation with filter on exhaust fans	***5***	0	0	0	0	0	0
256	livestock building air quality managed by forced ventilation, no filter	***4***	0	0	0	0	0	0
257	livestock building air quality managed by passive/natural ventilation	***2***	0	0	0	0	0	0
258								
259	livestock building ventilation rate controlled by fans switched on automatically	***5***	0	0	0	0	0	0
260	livestock building ventilation rate controlled by fans switched on manually	***3***	0	0	0	0	0	0
261								
262	exhaust fan filter changed every month	***5***	0	0	0	0	0	0
263	exhaust fan filter changed every 2-5 months	***4***	0	0	0	0	0	0
264	exhaust fan filter changed every 6-11 months	***3***	0	0	0	0	0	0
265	exhaust fan filter changed every year	***2***	0	0	0	0	0	0
266	exhaust fan filter changed less frequently than every year	***1***	0	0	0	0	0	0
267								
268	**liquid manure storage**							
269	liquid or semi-solid manure system - earthen manure/lagoon system	***4***	0	0	0	0	0	0
270	liquid or semi-solid manure system - open/covered tank	***5***	0	0	0	0	0	0
271	liquid or semi-solid manure system - tank pit below slats	***4***	0	0	0	0	0	0
272								
273	storage capacity of liquid or semi solid manure system - less than 100 days	***1***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
274	storage capacity of liquid or semi solid manure system - 100-150 days	***1***	0	0	0	0	0	0
275	storage capacity of liquid or semi solid manure system - 151-200 days	***2***	0	0	0	0	0	0
276	storage capacity of liquid or semi solid manure system - 201-250 days	***3***	0	0	0	0	0	0
277	storage capacity of liquid or semi solid manure system - 251-300 days	***4***	0	0	0	0	0	0
278	storage capacity of liquid or semi solid manure system - 301-350 days	***5***	0	0	0	0	0	0
279	storage capacity of liquid or semi solid manure system - 351 and more days	***5***	0	0	0	0	0	0
280								
281	liquid or semi-solid manure system is covered	***5***	0	0	0	0	0	0
282	liquid or semi-solid manure system is not covered	***1***	0	0	0	0	0	0
283								
284	cover on liquid or semi-solid manure storage system - crust	***3***	0	0	0	0	0	0
285	cover on liquid or semi-solid manure storage system - straw	***2***	0	0	0	0	0	0
286	cover on liquid or semi-solid manure storage system - lid	***5***	0	0	0	0	0	0
287	cover on liquid or semi-solid manure storage system - tarp	***5***	0	0	0	0	0	0
288								
289	floor of liquid or semi-solid manure storage system - concrete	***5***	0	0	0	0	0	0
290	floor of liquid or semi-solid manure storage system - steel	***5***	0	0	0	0	0	0
291	floor of liquid or semi-solid manure storage system - geomembrane	***5***	0	0	0	0	0	0
292	floor of liquid or semi-solid manure storage system - compacted soil/clay	***4***	0	0	0	0	0	0
293	floor of liquid or semi-solid manure storage system - porous	***1***						
294								

	A	B	C	D	E	F	G	H
3			**Soil**					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
295	wall of liquid or semi-solid manure storage system - concrete	***5***	0	0	0	0	0	0
296	wall of liquid or semi-solid manure storage system - steel	***5***	0	0	0	0	0	0
297	wall of liquid or semi-solid manure storage system - geomembrane	***5***	0	0	0	0	0	0
298	wall of liquid or semi-solid manure storage system - compacted soil/clay	***4***	0	0	0	0	0	0
299	floor of liquid or semi-solid manure storage system - porous	***1***	0	0	0	0	0	0
300								
301	**liquid manure treatment**							
302	liquid or semi-solid manure aerated or agitated	***3***	0	0	0	0	0	0
303	liquid or semi-solid manure filtered through a marsh/constructed wetland	***3***	0	0	0	0	0	0
304	liquid or semi-solid manure digested in an anaerobic digestor system	***5***	0	0	0	0	0	0
305	liquid or semi-solid manure mixed with additives to modify odour, ph or nutrient retention	***3***	0	0	0	0	0	0
306	liquid or semi-solid manure mixed or turned to accelerate composting	***4***	0	0	0	0	0	0
307	liquid or semi-solid manure processed to separate liquid from solid	***4***	0	0	0	0	0	0
308	liquid or semi-solid manure dried	***3***	0	0	0	0	0	0
309	no treatment for liquid or semi-solid manure	***1***	0	0	0	0	0	0
310								
311	**liquid manure disposal**							
312	fate of liquid or semi-solid manure - spread on land of operation	***4***	0	0	0	0	0	0
313	fate of liquid or semi-solid manure - sold or given to others	***4***	0	0	0	0	0	0
314	fate of liquid or semi-solid manure - removed by contractor	***4***	0	0	0	0	0	0
315								

	A	B	C	D	E	F	G	H
3			**Soil**					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
316	**solid manure storage**							
317	solid manure storage system - pile on the ground near livestock building	***3***	0	0	0	0	0	0
318	solid manure storage system - pile on ground near land application sites	***3***	0	0	0	0	0	0
319	solid manure storage system - manure packs in barns, pens, corrals, feeding sites	***3***	0	0	0	0	0	0
320								
321	pile on ground near livestock building on impermeable pad	***5***	0	0	0	0	0	0
322	pile on ground near livestock building not on impermeable pad	***1***	0	0	0	0	0	0
323	pile on ground near livestock building has runoff containment system	***5***	0	0	0	0	0	0
324	pile on ground near livestock building does not have runoff containment system	***1***	0	0	0	0	0	0
325	pile on ground near livestock building has roof or cover	***5***	0	0	0	0	0	0
326	pile on ground near livestock building does not have roof or cover	***1***	0	0	0	0	0	0
327								
328	pile on ground near land application site on impermeable pad	***5***	0	0	0	0	0	0
329	pile on ground near land application site not on impermeable pad	***1***	0	0	0	0	0	0
330	pile on ground near land application site has runoff containment system	***5***	0	0	0	0	0	0
331	pile on ground near land application site does not have runoff containment system	***1***	0	0	0	0	0	0
332	pile on ground near land application site has roof or cover	***5***	0	0	0	0	0	0
333	pile on ground near land application site does not have roof or cover	***1***	0	0	0	0	0	0
334								
335	manure pack in barn, pen, corral, feeding site on impermeable pad	***5***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
336	manure pack in barn, pen, corral, feeding site not on impermeable pad	***1***	0	0	0	0	0	0
337	manure pack in barn, pen, corral, feeding site has runoff containment system	***5***	0	0	0	0	0	0
338	manure pack in barn, pen, corral, feeding site does not have runoff containment system	***1***	0	0	0	0	0	0
339	manure pack in barn, pen, corral, feeding site has roof or cover	***5***	0	0	0	0	0	0
340	manure pack in barn, pen, corral, feeding site does not have roof or cover	***1***	0	0	0	0	0	0
341								
342								
343	manure collected from December to March stored for less than one month	***1***	0	0	0	0	0	0
344	manure collected from December to March stored for 1 month to less than 6 months	***2***	0	0	0	0	0	0
345	manure collected from December to March stored for 6 months to less than 12 months	***5***	0	0	0	0	0	0
346	manure collected from December to March stored for 12 months and longer	***2***	0	0	0	0	0	0
347	manure collected from December to March not stored over winter	***1***	0	0	0	0	0	0
348								
349	manure collected from April to November stored for less than one month	***4***	0	0	0	0	0	0
350	manure collected from April to November stored for 1 month to less than 6 months	***3***	0	0	0	0	0	0
351	manure collected from April to November stored for 6 months to less than 12 months	***1***	0	0	0	0	0	0
352	manure collected from April to November stored for 12 months and longer	***2***	0	0	0	0	0	0

	A	B	C	D	E	F	G	H
3			**Soil**					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
353	manure collected from April to November not stored over spring to fall	***4***	0	0	0	0	0	0
354								
355	**solid manure treatment**							
356	solid manure mixed with additives to modify odour, ph or nutrient retention	***3***	0	0	0	0	0	0
357	solid manure mixed or turned to accelerate composting	***3***	0	0	0	0	0	0
358	solid manure had other treatments	***3***	0	0	0	0	0	0
359	solid manure was not treated	***1***	0	0	0	0	0	0
360								
361	**solid manure disposal**							
362	fate of solid manure - spread on the land operated	***4***	0	0	0	0	0	0
363	fate of solid manure - sold or given to others	***4***	0	0	0	0	0	0
364	fate of solid manure - removed by contractor	***4***	0	0	0	0	0	0
365								
366	**Grazing management**							
367	practice rotational grazing	***5***	0	0	0	0	0	0
368	do not practice rotational grazing	***1***	0	0	0	0	0	0
369								
370	pasture seeded every 1-2 years	***1***	0	0	0	0	0	4
371	pasture seeded every 3-5 years	***2***	0	0	0	0	0	4
372	pasture seeded every 6-10 years	***3***	0	0	0	0	0	4
373	pasture seeded every 11-15 years	***3***	0	0	0	0	0	0
374	pasture seeded every 16 years or more	***3***	0	0	0	0	0	0
375	pasture never re-seeded	***3***	0	0	0	0	0	0
376								

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
377	extend grazing season by using forages that grow in early spring	***5***	0	0	0	0	0	5
378	extend grazing season by using foragest that grow in late fall	***5***	0	0	0	0	0	5
379	extend grazing season by supplementing grazing areas with additional hay	***4***	0	0	0	0	0	0
380	extend grazing season by grazing swathed or cut/windrowed crops during winter	***4***	0	0	0	0	0	0
381	extend grazing season by grazing standing vegetation or annual crop residues over winter	***4***	0	0	0	0	0	0
382	no methods used to extend grazing season	***2***	0	0	0	0	0	0
383								
384	when feeding livestock in an open feeding area, feeding sites are moved to different locations	***5***	0	0	0	0	0	0
385	when feeding livestock in an open feeding area, watering sites are moved to different locations	***4***	0	0	0	0	0	0
386	when feeding livestock in an open feeding area, sheltering sites are moved to different locations	***5***	0	0	0	0	0	0
387	when feeding livestock in an open feeding area, livestock remain in same area	***1***	0	0	0	0	0	0
388	no practices used when feeding livestock in an open feeding area	***1***	0	0	0	0	0	0
389								
390	grazing livestock have unlimited year round access to surface water	***1***	0	0	0	0	0	0
391	grazing livestock have unlimited access to surface water for entire grazing season	***1***	0	0	0	0	0	0
392	grazing livestock have unlimited access to surface water for winter feeding season	***1***	0	0	0	0	0	0
393	grazing livestock have limited access to surface water	***2***	0	0	0	0	0	0
394	grazing livestock have no access to surface water	***5***	0	0	0	0	0	0
395								

	A	B	C	D	E	F	G	H
3			Soil					
4	**Practice**	***Overall ranking***	wind erosion	water erosion	tillage erosion	soil organic carbon	salinity	soil cover
396	livestock access to surface water is restricted by fencing the shoreline	***5***	0	0	0	0	0	0
397	livestock access to surface water is restricted through remote or offsite watering system to a trough	***5***	0	0	0	0	0	0
398	livestock access to surface water is restricted to access ramps for direct watering	***2***	0	0	0	0	0	0
399	livestock access to surface water is restricted to stream crossings	***2***	0	0	0	0	0	0
400	livestock access to surface water is restricted to limited or controlled grazing in riparian areas or adjacent to surface water	***3***	0	0	0	0	0	0
401								

	A	B	I	J	K	L	M
3			**Water**				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
5	**Tillage practices**						
6	Conventional tillage	***1***	1	1	1	0	2
7	Conservation tillage	***4***	4	5	3	0	4
8	No till/zero till	***5***	5	5	3	0	4
9							
10	practice crop rotation	***5***	0	0	0	0	0
11	do not practice crop rotation	***1***	0	0	0	0	0
12							
13	**Crop residue management**						
14	crop residues left on ground	***4***	4	5	0	0	4
15	chop and spread crop residues	***5***	4	5	0	0	4
16	spread residues without chopping	***4***	4	4	0	0	4
17	bale residues	***3***	1	1	0	0	1
18	burn crop residues	***1***	1	1	0	0	1
19	incorporate crop residues into soil	***1***	2	2	0	0	2
20	compost residues into a pile	***3***	0	0	0	0	1
21	collect (chaff portion) residues	***4***	0	0	0	0	1
22	crop residues grazed by livestock	***3***	2	2	0	0	1
23							
24	**fertilizer application methods**						
25	fertilizer applied with seed	***5***	5	5	0	0	0
26	fertilizer applied by subsurface application separate from seeding (shovel, knife, bander)	***4***	5	5	0	0	0
27	fertilizer applied by subsurface application during seeding in separate band away from seed (includes mid-row banding)	***5***	5	5	0	0	0
28	fertilizer applied by post-plant or post emergent application (top/side dressing)	***4***	3	3	0	0	0

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
29	fertilizer applied by surface broadcast and not incorporated	***2***	2	2	0	0	0
30	fertilizer applied by surface broadcast and incorporated	***3***	3	3	0	0	0
31	fertilizer applied by fertigation	***3***	3	3	0	0	0
32	fertilizer applied by foliar application	***3***	3	3	0	0	0
33							
34	**Soil testing practices**						
35	Soil testing every year	***5***	0	0	0	0	0
36	soil testing every 2-3 years	***4***	0	0	0	0	0
37	soil testing every 4-5 years	***3***	0	0	0	0	0
38	soil testing every 6 years or more	***2***	0	0	0	0	0
39	no soil testing	***1***	0	0	0	0	0
40							
41	**fertilizer application practices**						
42	quantity of fertilizer reduced due to manure application	***5***	5	5	0	0	0
43	quantity of fertilizer not reduced due to manure application	***1***	1	1	0	0	0
44							
45	fertilizer applied before seeding, or before new growth begins	***5***	5	5	0	0	0
46	fertilizer applied after seeding, before harvest or after new growth begins	***4***	4	4	0	0	0
47	fertilizer applied after harvest	***1***	1	1	0	0	0
48							
49	solid manure tested for nutrient content before application	***5***	0	0	0	0	0
50	solid manure not tested for nutreint content before application	***1***	0	0	0	0	0
51							
52	**Solid manure application timing**						
53	solid manure applied before crop growth	***5***	5	5	0	0	0

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
54	solid manure applied after crop growth began	***4***	4	4	0	0	0
55	solid manure applied after harvest (before ground is frozen)	***2***	2	2	0	0	0
56	solid manure applied on frozen ground	***1***	1	1	0	0	0
57							
58	**Solid manure application methods**						
59	application of solid manure - broadcast and incorporated	***5***	5	5	0	0	0
60	application of solid manure - broadcast and not incorporated	***1***	1	1	0	0	0
61							
62	**Solid manure incorporation practices**						
63	solid manure incorporated same day as application	***5***	5	5	0	1	0
64	solid manure incorporated 1-2 days after application	***4***	4	4	0	2	0
65	solid manure incorporated 3-5 days after application	***3***	3	3	0	4	0
66	solid manure incorporated more than 5 days after application	***2***	1	1	0	4	0
67	solid manure was not incorporated after application	***1***	1	1	0	4	0
68							
69	liquid or semi-solid manure tested for nutrient content before application	***5***	0	0	0	0	0
70	liquid or semi-solid manure not tested for nutreint content before application	***1***	0	0	0	0	0
71							
72	**Liquid manure application timing**						
73	liquid or semi-solid manure applied before crop growth	***5***	5	5	0	0	0
74	liquid or semi-solid manure applied after crop growth began	***4***	4	4	0	0	0
75	liquid or semi-solid manure applied after harvest (before ground is frozen)	***2***	2	2	0	0	0
76	liquid or semi-solid manure applied on frozen ground	***1***	1	1	0	0	0
77							
78	**liquid manure application methods**						

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
79	application of liquid or semi-solid manure - broadcast and incorporated into soil	***4***	4	4	0	0	0
80	application of liquid or semi-solid manure - broadcast and not incorporated	***1***	1	1	0	0	0
81	application of liquid or semi-solid manure - directly injected into the soil	***5***	5	5	0	0	0
82	application of liquid or semi-solid manure - applied below crop canopy or using low boom applicator	***4***	4	4	0	0	0
83	application of liquid or semi-solid manure - using irrigation system	***1***	1	1	0	0	0
84							
85	**Liquid manure incorporation timing**						
86	liquid or semi-solid manure incorporated same day as application	***5***	5	5	0	1	0
87	liquid or semi-solid manure incorporated 1-2 days after application	***4***	4	4	0	2	0
88	liquid or semi-solid manure incorporated 3-5 days after application	***3***	3	3	0	4	0
89	liquid or semi-solid manure incorporated more than 5 days after application	***2***	1	1	0	4	0
90							
91	**Pesticide application practices**						
92	formally certified pesticide applicator applied all pesticide applications	***5***	0	0	0	0	0
93	formally certified pesticide applicator applied some pesticide applications	***3***	0	0	0	0	0
94	formally certified pesticide applicator applied no pesticide applications	***2***	0	0	0	0	0
95							
96	pesticide sprayer calibrated when it breaks down	***2***	0	0	0	0	0
97	pesticide sprayer calibrated before the beginning of the crop season/before first application	***3***	0	0	0	0	0

	A	B	I	J	K	L	M
3			**Water**				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
98	pesticide sprayer calibrated between applications of different types of pesticides	***5***	0	0	0	0	0
99	pesticide sprayer not calibrated	***1***	0	0	0	0	0
100							
101	**Pesticide drift management**						
102	controlled pesticide drift by applying pesticides only when winds are below recommended thresholds	***4***	0	0	4	0	0
103	controlled pesticide drift by using low drift or low pressure nozzles	***4***	0	0	4	0	0
104	controlled pesticide drift by using shrouded booms	***4***	0	0	4	0	0
105	controlled pesticide drift by adding anti-drift agents or chemicals	***4***	0	0	4	0	0
106	controlled pesticide drift by leaving untreated buffer zones	***4***	0	0	4	0	0
107	no specific method employed to control pesticide drift	***1***	0	0	1	0	0
108							
109	**Pesticide reduction practices**						
110	methods to reduce the amount of pesticides used - use tracking, guidance, or marking systems to minimize overlap and misses	***4***	0	0	4	0	0
111	methods to reduce the amount of pesticides used - spray only target infested areas	***4***	0	0	4	0	0
112	methods to reduce the amount of pesticides used - use in line injection/mixing systems to eliminate unused tank mixes	***4***	0	0	4	0	0
113	methods to reduce the amount of pesticides used - apply smaller amounts than rate recommended on chemical product label	***3***	0	0	3	0	0
114	no specific method used to reduce amount of pesticides used	***1***	0	0	1	0	0
115							
116	**Alternative pest management practices**						

	A	B	I	J	K	L	M
3			**Water**				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
117	alternative methods to controlling weeds, insects or diseases - plant tolerant or resistant plants, varieties or cultivars	***5***	0	0	5	0	0
118	alternative methods to controlling weeds, insects or diseases - rotate crops to disrupt pest cycles	***5***	0	0	5	0	0
119	alternative methods to controlling weeds, insects or diseases - eliminate, remove or incorporate diseased plant, pruning residues or cull piles	***3***	2	2	3	0	0
120	alternative methods to controlling weeds, insects or diseases - plant green manure or cover crops	***5***	5	5	5	0	0
121	alternative methods to controlling weeds, insects or diseases - plant in the fall	***5***	5	5	5	0	0
122	alternative methods to controlling weeds, insects or diseases - use tillage implements	***3***	0	0	3	0	2
123	alternative methods to controlling weeds, insects or diseases - use hand weeding/hoeing	***5***	0	0	0	0	0
124	alternative methods to controlling weeds, insects or diseases - use covers or mulches	***5***	3	3	0	0	0
125	alternative methods to controlling weeds, insects or diseases - introduce natural enemies/biological control agents	***3***	0	0	0	0	0
126	alternative methods to controlling weeds, insects or diseases - lure or trap crops	***5***	0	0	0	0	0
127							
128	**land and water management practices**						
129	cover or companion crops seeded	***4***	4	4	0	0	5
130	winter cover or green manure crops seeded alone after previous crop harvest	***4***	5	5	0	0	5
131	strip cropping used	***4***	4	4	0	0	5
132	contour or across the slope cropping used	***4***	0	0	0	0	5
133	terracing used	***4***	0	0	0	0	5
134	permanent perennial forages planted on erodible land	***5***	4	5	0	0	5
135	straw mulching (spread straw) performed on erodible land	***4***	3	3	0	0	4

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
136	farmstead shelterbelts/windbreaks established	***5***	0	0	0	0	3
137	field shelterbelts (trees, shrubs) planted	***5***	0	0	0	0	3
138	land with surface or subsurface drainage (constructed surface water channels or tile drainage) present	***3***	2	0	0	1	0
139							
140	**surface water management**						
141	maintaining a riparian buffer along a seasonal wetland	***5***	5	5	5	5	5
142	did not maintain a riparian buffer along a seasonal wetland	***1***	1	1	1	1	1
143	maintaining a riparian buffer along a permanent wetland	***5***	5	5	5	5	5
144	did not maintain a riparian buffer along a permanent wetland	***1***	1	1	1	1	1
145	maintaining a riparian buffer along a waterway	***5***	5	5	5	5	5
146	did not maintain a riparian buffer along a waterway	***1***	1	1	1	1	1
147							
148	maintainging a setback distance around a seasonal wetland	***5***	5	5	5	5	5
149	did not maintain a setback distance around a seasonal wetland	***1***	1	1	1	1	1
150	maintainging a setback distance around a permanent wetland	***5***	5	5	5	5	5
151	did not maintain a setback distance around a permanent wetland	***1***	1	1	1	1	1
152	maintainging a setback distance around a waterway	***5***	5	5	5	5	5
153	did not maintain a setback distance around a waterway	***1***	1	1	1	1	1
154							
155	stabilizing shorelines or banks around a permanent wetland	***5***	0	0	0	0	5
156	did not stabilize shorelines or banks around a permanent wetland	***1***	0	0	0	0	1
157	stabilizing shorelines or banks around a seasonal wetland	***5***	0	0	0	0	5
158	did not stabilize shorelines or banks around a seasonal wetland	***1***	0	0	0	0	1

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
159	stabilizing shorelines or banks along a waterway	***5***	0	0	0	0	5
160	did not stabilize shorelines or banks along a waterway	***1***	0	0	0	0	1
161							
162	**well water quality**						
163	test water quality in active wells at least once a year	***5***	0	0	0	0	0
164	test water quality in active wells every 2 years	***4***	0	0	0	0	0
165	test water quality in active wells every 3-5 years	***3***	0	0	0	0	0
166	test water quality in active wells every 6 years or more	***2***	0	0	0	0	0
167	never test water quality in active wells	***1***	0	0	0	0	0
168	water quality in active wells not tested, not a concern	***0***	0	0	0	0	0
169							
170	all abandoned water wells decommissioned	***5***	0	0	0	0	0
171	some abandoned water wells decommissioned	***3***	0	0	0	0	0
172	no abandoned water wells decommissioned	***1***	0	0	0	0	0
173							
174							
175	**Hazardous material storage and disposal management**						
176	Commercial fertilizer storage in a building with a concrete floor or pad	***5***	0	0	0	0	0
177	Commercial fertilizer storage in a building without a concrete floor or pad	***2***	0	0	0	0	0
178	Commercial fertilizer storage in an above ground sealed tank	***5***	0	0	0	0	0
179	Commercial fertilizer not stored on farm operation	***5***	0	0	0	0	0
180							
181	Pesticides stored in a building with a concrete floor or pad	***5***	0	0	0	0	0
182	Pesticides stored in a building without a concrete floor or pad	***2***	0	0	0	0	0
183	Pesticides stored in an above ground sealed tank	***5***	0	0	0	0	0

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
184	Pesticides not stored on farm operation	***5***	0	0	0	0	0
185							
186	fuel storage in a building with a concrete floor or pad	***5***	0	0	0	0	0
187	fuel storage in a building without a concrete floor or pad	***2***	0	0	0	0	0
188	fuel storage in an above ground sealed tank	***5***	0	0	0	0	0
189	fuel not stored on farm operation	***5***	0	0	0	0	0
190							
191	oil and grease stored in a building with a concrete floor or pad	***5***	0	0	0	0	0
192	oil and grease stored in a building without a concrete floor or pad	***2***	0	0	0	0	0
193	oil and grease stored in an above ground sealed tank	***5***	0	0	0	0	0
194	oil and grease not stored on farm operation	***5***	0	0	0	0	0
195							
196	containment system to handle spills - commercial fertilizers	***5***	0	0	0	0	0
197	no containmnet system to handle spills - commercial fertilizers	***1***	0	0	0	0	0
198	containment system to handle spills - pesticides	***5***	0	0	0	0	0
199	no containmnet system to handle spills - pesticides	***1***	0	0	0	0	0
200	containment system to handle spills - fuel	***5***	0	0	0	0	0
201	no containmnet system to handle spills - fuel	***1***	0	0	0	0	0
202	containment system to handle spills - oil and grease	***5***	0	0	0	0	0
203	no containmnet system to handle spills - oil and grease	***1***	0	0	0	0	0
204							
205	Commercial fertilizer disposed on farm (incineration, burning, etc)	***1***	0	0	0	0	0
206	Commercial fertilizer disposed with domestic garbage	***1***	0	0	0	0	0
207	Commercial fertilizer disposed in a municipal recycling program	***5***	0	0	0	0	0

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
208	Commercial fertilizer disposed by returning to supplier	***5***	0	0	0	0	0
209	Commercial fertilizer disposed using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0
210	no commercial fertilizer disposal	***5***	0	0	0	0	0
211							
212	pesticides disposed of on farm (incineration, burning, etc)	***1***	0	0	0	0	0
213	pesticides disposed of with domestic garbage	***1***	0	0	0	0	0
214	pesticides disposed of in a municipal recycling program	***5***	0	0	0	0	0
215	pesticides disposed of by returning to supplier	***5***	0	0	0	0	0
216	pesticides disposed of using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0
217	no disposal of pesticides	***5***	0	0	0	0	0
218							
219	petroleum products disposed of on farm (incineration, burning, etc)	***1***	0	0	0	0	0
220	petroleum products disposed of with domestic garbage	***1***	0	0	0	0	0
221	petroleum products disposed of in a municipal recycling program	***5***	0	0	0	0	0
222	petroleum products disposed of by returning to supplier	***5***	0	0	0	0	0
223	petroleum products disposed of using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0
224	no disposal of petroleum products	***5***	0	0	0	0	0
225							
226	other hazardous materials disposed of on farm (incineration, burning, etc)	***1***	0	0	0	0	0
227	other hazardous materials disposed of with domestic garbage	***1***	0	0	0	0	0
228	other hazardous materials disposed of in a municipal recycling program	***5***	0	0	0	0	0
229	other hazardous materials disposed of by returning to supplier	***5***	0	0	0	0	0

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
230	other hazardous materials disposed of by using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0
231	no disposal of other hazardous materials	***5***	0	0	0	0	0
232							
233	**wastewater management**						
234	wastewater discharged to a septic or sewer system	***4***	0	0	0	5	0
235	wastewater discharged into a filtration marsh or wetland	***4***	0	0	0	4	0
236	wastewater included in the liquid manure system	***5***	0	0	0	5	0
237	wastewater collected in holding or storage tank	***5***	0	0	0	5	0
238	wastewater discharged to a constructed retention pond or holding pond	***4***	0	0	0	4	0
239	wastewater not actively managed	***1***	0	0	0	1	0
240							
241	**deadstock management**						
242	deadstock disposal - buried	***4***	0	0	0	0	0
243	deadstock disposal - incinerated	***3***	0	0	0	0	0
244	deadstock disposal - composted	***4***	0	0	0	0	0
245	deadstock disposal - off farm collection service	***5***	0	0	0	0	0
246							
247							
248	GPS used for collecting information for soil and crop management	***4***	0	0	0	0	0
249	GPS used for collecting information for water management	***4***	0	0	0	0	0
250	GPS used for as a tracking or guidance system on tractor to eliminate overlaps and misses on field	***5***	0	0	0	0	0
251	GPS used for targeting or varying fertilizer or manure application rate	***4***	0	0	0	0	0
252	GPS used for targeting or varying pesticide application rates	***4***	0	0	0	0	0

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
253							
254	**livestock housing air quality**						
255	livestock building air quality managed by forced ventilation with filter on exhaust fans	***5***	0	0	0	0	0
256	livestock building air quality managed by forced ventilation, no filter	***4***	0	0	0	0	0
257	livestock building air quality managed by passive/natural ventilation	***2***	0	0	0	0	0
258							
259	livestock building ventilation rate controlled by fans switched on automatically	***5***	0	0	0	0	0
260	livestock building ventilation rate controlled by fans switched on manually	***3***	0	0	0	0	0
261							
262	exhaust fan filter changed every month	***5***	0	0	0	0	0
263	exhaust fan filter changed every 2-5 months	***4***	0	0	0	0	0
264	exhaust fan filter changed every 6-11 months	***3***	0	0	0	0	0
265	exhaust fan filter changed every year	***2***	0	0	0	0	0
266	exhaust fan filter changed less frequently than every year	***1***	0	0	0	0	0
267							
268	**liquid manure storage**						
269	liquid or semi-solid manure system - earthen manure/lagoon system	***4***	0	0	0	0	0
270	liquid or semi-solid manure system - open/covered tank	***5***	0	0	0	0	0
271	liquid or semi-solid manure system - tank pit below slats	***4***	0	0	0	0	0
272							
273	storage capacity of liquid or semi solid manure system - less than 100 days	***1***	0	0	0	0	0

	A	B	I	J	K	L	M
3			**Water**				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
274	storage capacity of liquid or semi solid manure system - 100-150 days	***1***	0	0	0	0	0
275	storage capacity of liquid or semi solid manure system - 151-200 days	***2***	0	0	0	0	0
276	storage capacity of liquid or semi solid manure system - 201-250 days	***3***	0	0	0	0	0
277	storage capacity of liquid or semi solid manure system - 251-300 days	***4***	0	0	0	0	0
278	storage capacity of liquid or semi solid manure system - 301-350 days	***5***	0	0	0	0	0
279	storage capacity of liquid or semi solid manure system - 351 and more days	***5***	0	0	0	0	0
280							
281	liquid or semi-solid manure system is covered	***5***	0	0	0	0	0
282	liquid or semi-solid manure system is not covered	***1***	0	0	0	0	0
283							
284	cover on liquid or semi-solid manure storage system - crust	***3***	0	0	0	0	0
285	cover on liquid or semi-solid manure storage system - straw	***2***	0	0	0	0	0
286	cover on liquid or semi-solid manure storage system - lid	***5***	0	0	0	0	0
287	cover on liquid or semi-solid manure storage system - tarp	***5***	0	0	0	0	0
288							
289	floor of liquid or semi-solid manure storage system - concrete	***5***	5	5	0	5	0
290	floor of liquid or semi-solid manure storage system - steel	***5***	5	5	0	5	0
291	floor of liquid or semi-solid manure storage system - geomembrane	***5***	5	5	0	5	0
292	floor of liquid or semi-solid manure storage system - compacted soil/clay	***4***	4	4	0	4	0
293	floor of liquid or semi-solid manure storage system - porous	***1***	1	1			
294							

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
295	wall of liquid or semi-solid manure storage system - concrete	***5***	5	5	0	5	0
296	wall of liquid or semi-solid manure storage system - steel	***5***	5	5	0	5	0
297	wall of liquid or semi-solid manure storage system - geomembrane	***5***	5	5	0	5	0
298	wall of liquid or semi-solid manure storage system - compacted soil/clay	***4***	4	4	0	4	0
299	floor of liquid or semi-solid manure storage system - porous	***1***	1	1	0	1	0
300							
301	**liquid manure treatment**						
302	liquid or semi-solid manure aerated or agitated	***3***	0	0	0	0	0
303	liquid or semi-solid manure filtered through a marsh/constructed wetland	***3***	0	0	0	0	0
304	liquid or semi-solid manure digested in an anaerobic digestor system	***5***	0	0	0	0	0
305	liquid or semi-solid manure mixed with additives to modify odour, ph or nutrient retention	***3***	0	0	0	0	0
306	liquid or semi-solid manure mixed or turned to accelerate composting	***4***	0	0	0	4	0
307	liquid or semi-solid manure processed to separate liquid from solid	***4***	0	0	0	0	0
308	liquid or semi-solid manure dried	***3***	0	0	0	4	0
309	no treatment for liquid or semi-solid manure	***1***	0	0	0	1	0
310							
311	**liquid manure disposal**						
312	fate of liquid or semi-solid manure - spread on land of operation	***4***	0	0	0	0	0
313	fate of liquid or semi-solid manure - sold or given to others	***4***	0	0	0	0	0
314	fate of liquid or semi-solid manure - removed by contractor	***4***	0	0	0	0	0
315							

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
316	**solid manure storage**						
317	solid manure storage system - pile on the ground near livestock building	***3***	0	0	0	0	0
318	solid manure storage system - pile on ground near land application sites	***3***	0	0	0	0	0
319	solid manure storage system - manure packs in barns, pens, corrals, feeding sites	***3***	0	0	0	0	0
320							
321	pile on ground near livestock building on impermeable pad	***5***	5	5	0	5	0
322	pile on ground near livestock building not on impermeable pad	***1***	1	1	0	1	0
323	pile on ground near livestock building has runoff containment system	***5***	5	5	0	5	0
324	pile on ground near livestock building does not have runoff containment system	***1***	1	1	0	1	0
325	pile on ground near livestock building has roof or cover	***5***	0	0	0	0	0
326	pile on ground near livestock building does not have roof or cover	***1***	0	0	0	0	0
327							
328	pile on ground near land application site on impermeable pad	***5***	5	5	0	5	0
329	pile on ground near land application site not on impermeable pad	***1***	1	1	0	1	0
330	pile on ground near land application site has runoff containment system	***5***	5	5	0	5	0
331	pile on ground near land application site does not have runoff containment system	***1***	1	1	0	1	0
332	pile on ground near land application site has roof or cover	***5***	0	0	0	0	0
333	pile on ground near land application site does not have roof or cover	***1***	0	0	0	0	0
334							
335	manure pack in barn, pen, corral, feeding site on impermeable pad	***5***	5	5	0	5	0

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
336	manure pack in barn, pen, corral, feeding site not on impermeable pad	***1***	1	1	0	1	0
337	manure pack in barn, pen, corral, feeding site has runoff containment system	***5***	5	5	0	5	0
338	manure pack in barn, pen, corral, feeding site does not have runoff containment system	***1***	1	1	0	1	0
339	manure pack in barn, pen, corral, feeding site has roof or cover	***5***	0	0	0	0	0
340	manure pack in barn, pen, corral, feeding site does not have roof or cover	***1***	0	0	0	0	0
341							
342							
343	manure collected from December to March stored for less than one month	***1***	0	0	0	0	0
344	manure collected from December to March stored for 1 month to less than 6 months	***2***	0	0	0	0	0
345	manure collected from December to March stored for 6 months to less than 12 months	***5***	0	0	0	0	0
346	manure collected from December to March stored for 12 months and longer	***2***	0	0	0	0	0
347	manure collected from December to March not stored over winter	***1***	0	0	0	0	0
348							
349	manure collected from April to November stored for less than one month	***4***	0	0	0	0	0
350	manure collected from April to November stored for 1 month to less than 6 months	***3***	0	0	0	0	0
351	manure collected from April to November stored for 6 months to less than 12 months	***1***	0	0	0	0	0
352	manure collected from April to November stored for 12 months and longer	***2***	0	0	0	0	0

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
353	manure collected from April to November not stored over spring to fall	***4***	0	0	0	0	0
354							
355	**solid manure treatment**						
356	solid manure mixed with additives to modify odour, ph or nutrient retention	***3***	0	0	0	0	0
357	solid manure mixed or turned to accelerate composting	***3***	0	0	0	5	0
358	solid manure had other treatments	***3***	0	0	0	0	0
359	solid manure was not treated	***1***	0	0	0	1	0
360							
361	**solid manure disposal**						
362	fate of solid manure - spread on the land operated	***4***	0	0	0	0	0
363	fate of solid manure - sold or given to others	***4***	0	0	0	0	0
364	fate of solid manure - removed by contractor	***4***	0	0	0	0	0
365							
366	**Grazing management**						
367	practice rotational grazing	***5***	0	0	0	0	0
368	do not practice rotational grazing	***1***	0	0	0	0	0
369							
370	pasture seeded every 1-2 years	***1***	0	0	0	0	0
371	pasture seeded every 3-5 years	***2***	0	0	0	0	0
372	pasture seeded every 6-10 years	***3***	0	0	0	0	0
373	pasture seeded every 11-15 years	***3***	0	0	0	0	0
374	pasture seeded every 16 years or more	***3***	0	0	0	0	0
375	pasture never re-seeded	***3***	0	0	0	0	0
376							

	A	B	I	J	K	L	M
3			Water				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
377	extend grazing season by using forages that grow in early spring	***5***	0	0	0	0	0
378	extend grazing season by using foragest that grow in late fall	***5***	0	0	0	0	0
379	extend grazing season by supplementing grazing areas with additional hay	***4***	0	0	0	0	0
380	extend grazing season by grazing swathed or cut/windrowed crops during winter	***4***	0	0	0	0	0
381	extend grazing season by grazing standing vegetation or annual crop residues over winter	***4***	0	0	0	0	0
382	no methods used to extend grazing season	***2***	0	0	0	0	0
383							
384	when feeding livestock in an open feeding area, feeding sites are moved to different locations	***5***	5	5	0	0	0
385	when feeding livestock in an open feeding area, watering sites are moved to different locations	***4***	5	5	0	0	0
386	when feeding livestock in an open feeding area, sheltering sites are moved to different locations	***5***	5	5	0	0	0
387	when feeding livestock in an open feeding area, livestock remain in same area	***1***	2	2	0	0	0
388	no practices used when feeding livestock in an open feeding area	***1***	1	1	0	0	0
389							
390	grazing livestock have unlimited year round access to surface water	***1***	1	1	0	1	0
391	grazing livestock have unlimited access to surface water for entire grazing season	***1***	1	1	0	1	0
392	grazing livestock have unlimited access to surface water for winter feeding season	***1***	1	1	0	1	0
393	grazing livestock have limited access to surface water	***2***	2	2	0	2	0
394	grazing livestock have no access to surface water	***5***	5	5	0	5	0
395							

	A	B	I	J	K	L	M
3			**Water**				
4	**Practice**	***Overall ranking***	nitrogen contamination	phosphorus contamination	pesticide contamination	pathogen contamination	sedimentation of waterways
396	livestock access to surface water is restricted by fencing the shoreline	***5***	5	5	0	5	0
397	livestock access to surface water is restricted through remote or offsite watering system to a trough	***5***	5	5	0	5	0
398	livestock access to surface water is restricted to access ramps for direct watering	***2***	1	1	0	1	5
399	livestock access to surface water is restricted to stream crossings	***2***	1	1	0	1	4
400	livestock access to surface water is restricted to limited or controlled grazing in riparian areas or adjacent to surface water	***3***	2	2	0	2	0
401							

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
5	**Tillage practices**							
6	Conventional tillage	***1***	1	2	0	0	1	3
7	Conservation tillage	***4***	4	4	0	0	3	0
8	No till/zero till	***5***	4	4	0	0	4	4
9								
10	practice crop rotation	***5***	0	0	0	0	0	5
11	do not practice crop rotation	***1***	0	0	0	0	0	1
12								
13	**Crop residue management**							
14	crop residues left on ground	***4***	3	4	0	0	4	4
15	chop and spread crop residues	***5***	3	5	0	0	4	5
16	spread residues without chopping	***4***	3	4	0	0	4	4
17	bale residues	***3***	0	2	0	0	0	2
18	burn crop residues	***1***	1	1	0	0	0	2
19	incorporate crop residues into soil	***1***	1	2	0	0	0	3
20	compost residues into a pile	***3***	0	0	0	0	0	0
21	collect (chaff portion) residues	***4***	0	0	0	0	0	0
22	crop residues grazed by livestock	***3***	0	0	0	0	0	0
23								
24	**fertilizer application methods**							
25	fertilizer applied with seed	***5***	0	0	4	0	0	0
26	fertilizer applied by subsurface application separate from seeding (shovel, knife, bander)	***4***	0	0	4	0	0	0
27	fertilizer applied by subsurface application during seeding in separate band away from seed (includes mid-row banding)	***5***	0	0	4	0	0	0
28	fertilizer applied by post-plant or post emergent application (top/side dressing)	***4***	0	0	3	0	0	0

	A	B	N	O	P	Q	R	S
3			**Air**				**Biodiversity**	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
29	fertilizer applied by surface broadcast and not incorporated	***2***	0	0	2	0	0	0
30	fertilizer applied by surface broadcast and incorporated	***3***	0	0	4	0	0	0
31	fertilizer applied by fertigation	***3***	0	0	2	0	0	0
32	fertilizer applied by foliar application	***3***	0	0	2	0	0	0
33								
34	**Soil testing practices**							
35	Soil testing every year	***5***	0	0	0	0	0	0
36	soil testing every 2-3 years	***4***	0	0	0	0	0	0
37	soil testing every 4-5 years	***3***	0	0	0	0	0	0
38	soil testing every 6 years or more	***2***	0	0	0	0	0	0
39	no soil testing	***1***	0	0	0	0	0	0
40								
41	**fertilizer application practices**							
42	quantity of fertilizer reduced due to manure application	***5***	0	0	0	0	0	0
43	quantity of fertilizer not reduced due to manure application	***1***	0	0	0	0	0	0
44								
45	fertilizer applied before seeding, or before new growth begins	***5***	0	0	0	0	0	0
46	fertilizer applied after seeding, before harvest or after new growth begins	***4***	0	0	0	0	0	0
47	fertilizer applied after harvest	***1***	0	0	0	0	0	0
48								
49	solid manure tested for nutrient content before application	***5***	0	0	0	0	0	0
50	solid manure not tested for nutreint content before application	***1***	0	0	0	0	0	0
51								
52	**Solid manure application timing**							
53	solid manure applied before crop growth	***5***	0	0	0	0	0	0

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
54	solid manure applied after crop growth began	***4***	0	0	0	0	0	0
55	solid manure applied after harvest (before ground is frozen)	***2***	0	0	0	0	0	0
56	solid manure applied on frozen ground	***1***	0	0	0	1	0	0
57								
58	**Solid manure application methods**							
59	application of solid manure - broadcast and incorporated	***5***	0	0	5	5	0	0
60	application of solid manure - broadcast and not incorporated	***1***	0	0	1	1	0	0
61								
62	**Solid manure incorporation practices**							
63	solid manure incorporated same day as application	***5***	0	0	5	5	0	0
64	solid manure incorporated 1-2 days after application	***4***	0	0	4	4	0	0
65	solid manure incorporated 3-5 days after application	***3***	0	0	3	3	0	0
66	solid manure incorporated more than 5 days after application	***2***	0	0	2	2	0	0
67	solid manure was not incorporated after application	***1***	0	0	1	1	0	0
68								
69	liquid or semi-solid manure tested for nutrient content before application	***5***	0	0	0	0	0	0
70	liquid or semi-solid manure not tested for nutreint content before application	***1***	0	0	0	0	0	0
71								
72	**Liquid manure application timing**							
73	liquid or semi-solid manure applied before crop growth	***5***	0	0	0	0	0	0
74	liquid or semi-solid manure applied after crop growth began	***4***	0	0	0	0	0	0
75	liquid or semi-solid manure applied after harvest (before ground is frozen)	***2***	0	0	0	0	0	0
76	liquid or semi-solid manure applied on frozen ground	***1***	0	0	0	1	0	0
77								
78	**liquid manure application methods**							

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
79	application of liquid or semi-solid manure - broadcast and incorporated into soil	***4***	0	0	5	5	0	0
80	application of liquid or semi-solid manure - broadcast and not incorporated	***1***	0	0	1	1	0	0
81	application of liquid or semi-solid manure - directly injected into the soil	***5***	0	0	5	5	0	0
82	application of liquid or semi-solid manure - applied below crop canopy or using low boom applicator	***4***	0	0	2	3	0	0
83	application of liquid or semi-solid manure - using irrigation system	***1***	0	0	1	1	0	0
84								
85	**Liquid manure incorporation timing**							
86	liquid or semi-solid manure incorporated same day as application	***5***	0	0	5	5	0	0
87	liquid or semi-solid manure incorporated 1-2 days after application	***4***	0	0	4	4	0	0
88	liquid or semi-solid manure incorporated 3-5 days after application	***3***	0	0	2	1	0	0
89	liquid or semi-solid manure incorporated more than 5 days after application	***2***	0	0	1	1	0	0
90								
91	**Pesticide application practices**							
92	formally certified pesticide applicator applied all pesticide applications	***5***	0	0	0	0	0	0
93	formally certified pesticide applicator applied some pesticide applications	***3***	0	0	0	0	0	0
94	formally certified pesticide applicator applied no pesticide applications	***2***	0	0	0	0	0	0
95								
96	pesticide sprayer calibrated when it breaks down	***2***	0	0	0	0	0	0
97	pesticide sprayer calibrated before the beginning of the crop season/before first application	***3***	0	0	0	0	0	0

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
98	pesticide sprayer calibrated between applications of different types of pesticides	***5***	0	0	0	0	0	0
99	pesticide sprayer not calibrated	***1***	0	0	0	0	0	0
100								
101	**Pesticide drift management**							
102	controlled pesticide drift by applying pesticides only when winds are below recommended thresholds	***4***	0	0	0	0	0	0
103	controlled pesticide drift by using low drift or low pressure nozzles	***4***	0	0	0	0	0	0
104	controlled pesticide drift by using shrouded booms	***4***	0	0	0	0	0	0
105	controlled pesticide drift by adding anti-drift agents or chemicals	***4***	0	0	0	0	0	0
106	controlled pesticide drift by leaving untreated buffer zones	***4***	0	0	0	0	0	0
107	no specific method employed to control pesticide drift	***1***	0	0	0	0	0	0
108								
109	**Pesticide reduction practices**							
110	methods to reduce the amount of pesticides used - use tracking, guidance, or marking systems to minimize overlap and misses	***4***	0	0	0	0	0	0
111	methods to reduce the amount of pesticides used - spray only target infested areas	***4***	0	0	0	0	0	0
112	methods to reduce the amount of pesticides used - use in line injection/mixing systems to eliminate unused tank mixes	***4***	0	0	0	0	0	0
113	methods to reduce the amount of pesticides used - apply smaller amounts than rate recommended on chemical product label	***3***	0	0	0	0	0	0
114	no specific method used to reduce amount of pesticides used	***1***	0	0	0	0	0	0
115								
116	**Alternative pest management practices**							

	A	B	N	O	P	Q	R	S
3			**Air**				**Biodiversity**	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
117	alternative methods to controlling weeds, insects or diseases - plant tolerant or resistant plants, varieties or cultivars	***5***	0	0	0	0	0	0
118	alternative methods to controlling weeds, insects or diseases - rotate crops to disrupt pest cycles	***5***	0	0	0	0	0	4
119	alternative methods to controlling weeds, insects or diseases - eliminate, remove or incorporate diseased plant, pruning residues or cull piles	***3***	0	0	0	0	0	4
120	alternative methods to controlling weeds, insects or diseases - plant green manure or cover crops	***5***	4	4	0	0	4	4
121	alternative methods to controlling weeds, insects or diseases - plant in the fall	***5***	4	4	0	0	4	4
122	alternative methods to controlling weeds, insects or diseases - use tillage implements	***3***	0	0	0	0	0	4
123	alternative methods to controlling weeds, insects or diseases - use hand weeding/hoeing	***5***	0	0	0	0	0	0
124	alternative methods to controlling weeds, insects or diseases - use covers or mulches	***5***	0	4	0	0	0	0
125	alternative methods to controlling weeds, insects or diseases - introduce natural enemies/biological control agents	***3***	0	0	0	0	0	4
126	alternative methods to controlling weeds, insects or diseases - lure or trap crops	***5***	0	0	0	0	0	0
127								
128	**land and water management practices**							
129	cover or companion crops seeded	***4***	4	4	0	0	0	0
130	winter cover or green manure crops seeded alone after previous crop harvest	***4***	4	4	0	0	5	4
131	strip cropping used	***4***	0	0	0	0	0	0
132	contour or across the slope cropping used	***4***	0	0	0	0	0	0
133	terracing used	***4***	0	0	0	0	0	0
134	permanent perennial forages planted on erodible land	***5***	5	4	0	0	5	4
135	straw mulching (spread straw) performed on erodible land	***4***	0	4	0	0	0	0

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
136	farmstead shelterbelts/windbreaks established	***5***	5	5	4	4	5	0
137	field shelterbelts (trees, shrubs) planted	***5***	5	5	4	4	5	0
138	land with surface or subsurface drainage (constructed surface water channels or tile drainage) present	***3***	0	0	0	0	0	0
139								
140	**surface water management**							
141	maintaining a riparian buffer along a seasonal wetland	***5***	5	0	0	0	5	0
142	did not maintain a riparian buffer along a seasonal wetland	***1***	1	0	0	0	1	0
143	maintaining a riparian buffer along a permanent wetland	***5***	5	0	0	0	5	0
144	did not maintain a riparian buffer along a permanent wetland	***1***	1	0	0	0	1	0
145	maintaining a riparian buffer along a waterway	***5***	5	0	0	0	5	0
146	did not maintain a riparian buffer along a waterway	***1***	1	0	0	0	1	0
147								
148	maintainging a setback distance around a seasonal wetland	***5***	0	0	0	0	0	0
149	did not maintain a setback distance around a seasonal wetland	***1***	0	0	0	0	0	0
150	maintainging a setback distance around a permanent wetland	***5***	0	0	0	0	0	0
151	did not maintain a setback distance around a permanent wetland	***1***	0	0	0	0	0	0
152	maintainging a setback distance around a waterway	***5***	0	0	0	0	0	0
153	did not maintain a setback distance around a waterway	***1***	0	0	0	0	0	0
154								
155	stabilizing shorelines or banks around a permanent wetland	***5***	0	0	0	0	0	0
156	did not stabilize shorelines or banks around a permanent wetland	***1***	0	0	0	0	0	0
157	stabilizing shorelines or banks around a seasonal wetland	***5***	0	0	0	0	0	0
158	did not stabilize shorelines or banks around a seasonal wetland	***1***	0	0	0	0	0	0

	A	B	N	O	P	Q	R	S
3			**Air**				**Biodiversity**	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
159	stabilizing shorelines or banks along a waterway	***5***	0	0	0	0	0	0
160	did not stabilize shorelines or banks along a waterway	***1***	0	0	0	0	0	0
161								
162	**well water quality**							
163	test water quality in active wells at least once a year	***5***	0	0	0	0	0	0
164	test water quality in active wells every 2 years	***4***	0	0	0	0	0	0
165	test water quality in active wells every 3-5 years	***3***	0	0	0	0	0	0
166	test water quality in active wells every 6 years or more	***2***	0	0	0	0	0	0
167	never test water quality in active wells	***1***	0	0	0	0	0	0
168	water quality in active wells not tested, not a concern	***0***	0	0	0	0	0	0
169								
170	all abandoned water wells decommissioned	***5***	0	0	0	0	0	0
171	some abandoned water wells decommissioned	***3***	0	0	0	0	0	0
172	no abandoned water wells decommissioned	***1***	0	0	0	0	0	0
173								
174								
175	**Hazardous material storage and disposal management**							
176	Commercial fertilizer storage in a building with a concrete floor or pad	***5***	0	0	0	0	0	0
177	Commercial fertilizer storage in a building without a concrete floor or pad	***2***	0	0	0	0	0	0
178	Commercial fertilizer storage in an above ground sealed tank	***5***	0	0	0	0	0	0
179	Commercial fertilizer not stored on farm operation	***5***	0	0	0	0	0	0
180								
181	Pesticides stored in a building with a concrete floor or pad	***5***	0	0	0	0	0	0
182	Pesticides stored in a building without a concrete floor or pad	***2***	0	0	0	0	0	0
183	Pesticides stored in an above ground sealed tank	***5***	0	0	0	0	0	0

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
184	Pesticides not stored on farm operation	***5***	0	0	0	0	0	0
185								
186	fuel storage in a building with a concrete floor or pad	***5***	0	0	0	0	0	0
187	fuel storage in a building without a concrete floor or pad	***2***	0	0	0	0	0	0
188	fuel storage in an above ground sealed tank	***5***	0	0	0	0	0	0
189	fuel not stored on farm operation	***5***	0	0	0	0	0	0
190								
191	oil and grease stored in a building with a concrete floor or pad	***5***	0	0	0	0	0	0
192	oil and grease stored in a building without a concrete floor or pad	***2***	0	0	0	0	0	0
193	oil and grease stored in an above ground sealed tank	***5***	0	0	0	0	0	0
194	oil and grease not stored on farm operation	***5***	0	0	0	0	0	0
195								
196	containment system to handle spills - commercial fertilizers	***5***	0	0	0	0	0	0
197	no containmnet system to handle spills - commercial fertilizers	***1***	0	0	0	0	0	0
198	containment system to handle spills - pesticides	***5***	0	0	0	0	0	0
199	no containmnet system to handle spills - pesticides	***1***	0	0	0	0	0	0
200	containment system to handle spills - fuel	***5***	0	0	0	0	0	0
201	no containmnet system to handle spills - fuel	***1***	0	0	0	0	0	0
202	containment system to handle spills - oil and grease	***5***	0	0	0	0	0	0
203	no containmnet system to handle spills - oil and grease	***1***	0	0	0	0	0	0
204								
205	Commercial fertilizer disposed on farm (incineration, burning, etc)	***1***	0	0	0	0	0	0
206	Commercial fertilizer disposed with domestic garbage	***1***	0	0	0	0	0	0
207	Commercial fertilizer disposed in a municipal recycling program	***5***	0	0	0	0	0	0

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
208	Commercial fertilizer disposed by returning to supplier	***5***	0	0	0	0	0	0
209	Commercial fertilizer disposed using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0	0
210	no commercial fertilizer disposal	***5***	0	0	0	0	0	0
211								
212	pesticides disposed of on farm (incineration, burning, etc)	***1***	0	0	0	0	0	0
213	pesticides disposed of with domestic garbage	***1***	0	0	0	0	0	0
214	pesticides disposed of in a municipal recycling program	***5***	0	0	0	0	0	0
215	pesticides disposed of by returning to supplier	***5***	0	0	0	0	0	0
216	pesticides disposed of using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0	0
217	no disposal of pesticides	***5***	0	0	0	0	0	0
218								
219	petroleum products disposed of on farm (incineration, burning, etc)	***1***	0	0	0	0	0	0
220	petroleum products disposed of with domestic garbage	***1***	0	0	0	0	0	0
221	petroleum products disposed of in a municipal recycling program	***5***	0	0	0	0	0	0
222	petroleum products disposed of by returning to supplier	***5***	0	0	0	0	0	0
223	petroleum products disposed of using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0	0
224	no disposal of petroleum products	***5***	0	0	0	0	0	0
225								
226	other hazardous materials disposed of on farm (incineration, burning, etc)	***1***	0	0	0	0	0	0
227	other hazardous materials disposed of with domestic garbage	***1***	0	0	0	0	0	0
228	other hazardous materials disposed of in a municipal recycling program	***5***	0	0	0	0	0	0
229	other hazardous materials disposed of by returning to supplier	***5***	0	0	0	0	0	0

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
230	other hazardous materials disposed of by using waste disposal sites for hazardous waste or dangerous goods	***5***	0	0	0	0	0	0
231	no disposal of other hazardous materials	***5***	0	0	0	0	0	0
232								
233	**wastewater management**							
234	wastewater discharged to a septic or sewer system	***4***	0	0	0	0	0	0
235	wastewater discharged into a filtration marsh or wetland	***4***	0	0	0	0	0	0
236	wastewater included in the liquid manure system	***5***	0	0	0	0	0	0
237	wastewater collected in holding or storage tank	***5***	0	0	0	0	0	0
238	wastewater discharged to a constructed retention pond or holding pond	***4***	0	0	0	0	0	0
239	wastewater not actively managed	***1***	0	0	0	0	0	0
240								
241	**deadstock management**							
242	deadstock disposal - buried	***4***	0	0	0	0	0	0
243	deadstock disposal - incinerated	***3***	0	0	0	0	0	0
244	deadstock disposal - composted	***4***	0	0	0	0	0	0
245	deadstock disposal - off farm collection service	***5***	0	0	0	0	0	0
246								
247								
248	GPS used for collecting information for soil and crop management	***4***	0	0	0	0	0	0
249	GPS used for collecting information for water management	***4***	0	0	0	0	0	0
250	GPS used for as a tracking or guidance system on tractor to eliminate overlaps and misses on field	***5***	0	0	0	0	0	0
251	GPS used for targeting or varying fertilizer or manure application rate	***4***	0	0	0	0	0	0
252	GPS used for targeting or varying pesticide application rates	***4***	0	0	0	0	0	0

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
253								
254	**livestock housing air quality**							
255	livestock building air quality managed by forced ventilation with filter on exhaust fans	***5***	0	5	5	5	0	0
256	livestock building air quality managed by forced ventilation, no filter	***4***	0	4	4	4	0	0
257	livestock building air quality managed by passive/natural ventilation	***2***	0	2	2	2	0	0
258								
259	livestock building ventilation rate controlled by fans switched on automatically	***5***	0	5	5	5	0	0
260	livestock building ventilation rate controlled by fans switched on manually	***3***	0	4	4	4	0	0
261								
262	exhaust fan filter changed every month	***5***	0	5	5	0	0	0
263	exhaust fan filter changed every 2-5 months	***4***	0	4	4	0	0	0
264	exhaust fan filter changed every 6-11 months	***3***	0	2	2	0	0	0
265	exhaust fan filter changed every year	***2***	0	1	1	0	0	0
266	exhaust fan filter changed less frequently than every year	***1***	0	1	1	0	0	0
267								
268	**liquid manure storage**							
269	liquid or semi-solid manure system - earthen manure/lagoon system	***4***	0	0	0	0	0	0
270	liquid or semi-solid manure system - open/covered tank	***5***	0	0	0	0	0	0
271	liquid or semi-solid manure system - tank pit below slats	***4***	0	0	0	0	0	0
272								
273	storage capacity of liquid or semi solid manure system - less than 100 days	***1***	0	0	0	0	0	0

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
274	storage capacity of liquid or semi solid manure system - 100-150 days	***1***	0	0	0	0	0	0
275	storage capacity of liquid or semi solid manure system - 151-200 days	***2***	0	0	0	0	0	0
276	storage capacity of liquid or semi solid manure system - 201-250 days	***3***	0	0	0	0	0	0
277	storage capacity of liquid or semi solid manure system - 251-300 days	***4***	0	0	0	0	0	0
278	storage capacity of liquid or semi solid manure system - 301-350 days	***5***	0	0	0	0	0	0
279	storage capacity of liquid or semi solid manure system - 351 and more days	***5***	0	0	0	0	0	0
280								
281	liquid or semi-solid manure system is covered	***5***	5	0	5	5	0	0
282	liquid or semi-solid manure system is not covered	***1***	1	0	1	1	0	0
283								
284	cover on liquid or semi-solid manure storage system - crust	***3***	3	0	3	4	0	0
285	cover on liquid or semi-solid manure storage system - straw	***2***	2	0	2	3	0	0
286	cover on liquid or semi-solid manure storage system - lid	***5***	5	0	5	5	0	0
287	cover on liquid or semi-solid manure storage system - tarp	***5***	5	0	5	5	0	0
288								
289	floor of liquid or semi-solid manure storage system - concrete	***5***	0	0	0	0	0	0
290	floor of liquid or semi-solid manure storage system - steel	***5***	0	0	0	0	0	0
291	floor of liquid or semi-solid manure storage system - geomembrane	***5***	0	0	0	0	0	0
292	floor of liquid or semi-solid manure storage system - compacted soil/clay	***4***	0	0	0	0	0	0
293	floor of liquid or semi-solid manure storage system - porous	***1***						
294								

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
295	wall of liquid or semi-solid manure storage system - concrete	***5***	0	0	0	0	0	0
296	wall of liquid or semi-solid manure storage system - steel	***5***	0	0	0	0	0	0
297	wall of liquid or semi-solid manure storage system - geomembrane	***5***	0	0	0	0	0	0
298	wall of liquid or semi-solid manure storage system - compacted soil/clay	***4***	0	0	0	0	0	0
299	floor of liquid or semi-solid manure storage system - porous	***1***	0	0	0	0	0	0
300								
301	**liquid manure treatment**							
302	liquid or semi-solid manure aerated or agitated	***3***	3	0	2	2	0	0
303	liquid or semi-solid manure filtered through a marsh/constructed wetland	***3***	0	0	3	3	0	0
304	liquid or semi-solid manure digested in an anaerobic digestor system	***5***	5	0	3	3	0	0
305	liquid or semi-solid manure mixed with additives to modify odour, ph or nutrient retention	***3***	0	0	0	0	0	0
306	liquid or semi-solid manure mixed or turned to accelerate composting	***4***	4	0	2	2	0	0
307	liquid or semi-solid manure processed to separate liquid from solid	***4***	0	0	3	3	0	0
308	liquid or semi-solid manure dried	***3***	0	0	3	3	0	0
309	no treatment for liquid or semi-solid manure	***1***	0	0	1	1	0	0
310								
311	**liquid manure disposal**							
312	fate of liquid or semi-solid manure - spread on land of operation	***4***	0	0	0	0	0	0
313	fate of liquid or semi-solid manure - sold or given to others	***4***	0	0	0	0	0	0
314	fate of liquid or semi-solid manure - removed by contractor	***4***	0	0	0	0	0	0
315								

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
316	**solid manure storage**							
317	solid manure storage system - pile on the ground near livestock building	***3***	0	0	0	0	0	0
318	solid manure storage system - pile on ground near land application sites	***3***	0	0	0	0	0	0
319	solid manure storage system - manure packs in barns, pens, corrals, feeding sites	***3***	0	0	0	0	0	0
320								
321	pile on ground near livestock building on impermeable pad	***5***	0	0	0	0	0	0
322	pile on ground near livestock building not on impermeable pad	***1***	0	0	0	0	0	0
323	pile on ground near livestock building has runoff containment system	***5***	0	0	0	0	0	0
324	pile on ground near livestock building does not have runoff containment system	***1***	0	0	0	0	0	0
325	pile on ground near livestock building has roof or cover	***5***	4	5	5	5	0	0
326	pile on ground near livestock building does not have roof or cover	***1***	1	1	1	1	0	0
327								
328	pile on ground near land application site on impermeable pad	***5***	0	0	0	0	0	0
329	pile on ground near land application site not on impermeable pad	***1***	0	0	0	0	0	0
330	pile on ground near land application site has runoff containment system	***5***	0	0	0	0	0	0
331	pile on ground near land application site does not have runoff containment system	***1***	0	0	0	0	0	0
332	pile on ground near land application site has roof or cover	***5***	4	5	5	5	0	0
333	pile on ground near land application site does not have roof or cover	***1***	1	1	1	1	0	0
334								
335	manure pack in barn, pen, corral, feeding site on impermeable pad	***5***	0	0	0	0	0	0

	A	B	N	O	P	Q	R	S
3			**Air**				**Biodiversity**	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
336	manure pack in barn, pen, corral, feeding site not on impermeable pad	***1***	0	0	0	0	0	0
337	manure pack in barn, pen, corral, feeding site has runoff containment system	***5***	0	0	0	0	0	0
338	manure pack in barn, pen, corral, feeding site does not have runoff containment system	***1***	0	0	0	0	0	0
339	manure pack in barn, pen, corral, feeding site has roof or cover	***5***	4	5	5	5	0	0
340	manure pack in barn, pen, corral, feeding site does not have roof or cover	***1***	1	1	1	1	0	0
341								
342								
343	manure collected from December to March stored for less than one month	***1***	0	0	0	0	0	0
344	manure collected from December to March stored for 1 month to less than 6 months	***2***	0	0	0	0	0	0
345	manure collected from December to March stored for 6 months to less than 12 months	***5***	0	0	0	0	0	0
346	manure collected from December to March stored for 12 months and longer	***2***	0	0	0	0	0	0
347	manure collected from December to March not stored over winter	***1***	0	0	0	0	0	0
348								
349	manure collected from April to November stored for less than one month	***4***	0	0	0	0	0	0
350	manure collected from April to November stored for 1 month to less than 6 months	***3***	0	0	0	0	0	0
351	manure collected from April to November stored for 6 months to less than 12 months	***1***	0	0	0	0	0	0
352	manure collected from April to November stored for 12 months and longer	***2***	0	0	0	0	0	0

	A	B	N	O	P	Q	R	S
3			**Air**				**Biodiversity**	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
353	manure collected from April to November not stored over spring to fall	***4***	0	0	0	0	0	0
354								
355	**solid manure treatment**							
356	solid manure mixed with additives to modify odour, ph or nutrient retention	***3***	0	0	2	2	0	0
357	solid manure mixed or turned to accelerate composting	***3***	3	0	2	2	0	0
358	solid manure had other treatments	***3***	0	0	3	3	0	0
359	solid manure was not treated	***1***	0	0	1	1	0	0
360								
361	**solid manure disposal**							
362	fate of solid manure - spread on the land operated	***4***	0	0	0	0	0	0
363	fate of solid manure - sold or given to others	***4***	0	0	0	0	0	0
364	fate of solid manure - removed by contractor	***4***	0	0	0	0	0	0
365								
366	**Grazing management**							
367	practice rotational grazing	***5***	0	0	0	0	0	0
368	do not practice rotational grazing	***1***	0	0	0	0	0	0
369								
370	pasture seeded every 1-2 years	***1***	0	0	0	0	0	0
371	pasture seeded every 3-5 years	***2***	0	0	0	0	0	0
372	pasture seeded every 6-10 years	***3***	0	0	0	0	0	0
373	pasture seeded every 11-15 years	***3***	0	0	0	0	0	0
374	pasture seeded every 16 years or more	***3***	0	0	0	0	0	0
375	pasture never re-seeded	***3***	0	0	0	0	0	0
376								

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
377	extend grazing season by using forages that grow in early spring	***5***	0	0	0	0	4	0
378	extend grazing season by using foragest that grow in late fall	***5***	0	0	0	0	4	0
379	extend grazing season by supplementing grazing areas with additional hay	***4***	0	0	0	0	3	0
380	extend grazing season by grazing swathed or cut/windrowed crops during winter	***4***	0	0	0	0	4	0
381	extend grazing season by grazing standing vegetation or annual crop residues over winter	***4***	0	0	0	0	4	0
382	no methods used to extend grazing season	***2***	0	0	0	0	1	0
383								
384	when feeding livestock in an open feeding area, feeding sites are moved to different locations	***5***	0	0	0	0	0	5
385	when feeding livestock in an open feeding area, watering sites are moved to different locations	***4***	0	0	0	0	0	5
386	when feeding livestock in an open feeding area, sheltering sites are moved to different locations	***5***	5	0	5	0	0	5
387	when feeding livestock in an open feeding area, livestock remain in same area	***1***	0	0	1	0	1	1
388	no practices used when feeding livestock in an open feeding area	***1***	1	0	1	0	1	1
389								
390	grazing livestock have unlimited year round access to surface water	***1***	0	0	0	0	0	0
391	grazing livestock have unlimited access to surface water for entire grazing season	***1***	0	0	0	0	0	0
392	grazing livestock have unlimited access to surface water for winter feeding season	***1***	0	0	0	0	0	0
393	grazing livestock have limited access to surface water	***2***	0	0	0	0	0	0
394	grazing livestock have no access to surface water	***5***	0	0	0	0	0	0
395								

	A	B	N	O	P	Q	R	S
3			Air				Biodiversity	
4	**Practice**	***Overall ranking***	greenhouse gas	primary particulate matter	ammonia	odour	habitat availability	invasive species
396	livestock access to surface water is restricted by fencing the shoreline	***5***	0	0	0	0	0	0
397	livestock access to surface water is restricted through remote or offsite watering system to a trough	***5***	0	0	0	0	0	0
398	livestock access to surface water is restricted to access ramps for direct watering	***2***	0	0	0	0	0	0
399	livestock access to surface water is restricted to stream crossings	***2***	0	0	0	0	0	0
400	livestock access to surface water is restricted to limited or controlled grazing in riparian areas or adjacent to surface water	***3***	0	0	0	0	0	0
401								

APPENDIX 4 – JUSTIFICATIONS AND REFERENCES FOR RANKINGS IN TABLE 3

The following are the notes associated with Table 3. Each note is referenced by its cell number. Values in brackets following the cell number is the ranking assigned to the cell.

C6: (1) conventional tillage results in high disturbance of the soil, breakup of aggregates and incorporation of residues leave soil bare and vulnerable to erosion by wind.

D6: (1) conventional tillage results in high disturbance of the soil, breakup of aggregates and incorporation of residues leave soil bare and vulnerable to erosion by water.

E6: (1) turning over the soil by conventional tillage may result in soil losses.

F6: (1) tillage has been shown to cause depletion of soil organic matter in surface soils

(Wyland et al. 1996, Caporali and Onnis 1992).

I6: (1) according to Tong and Naramngam (2007), N loss increases as plowing increases.

J6: (1) increased erosion by wind and water increase risk of P transport to waterways.

N6: (1) machinery used to till soil emits greenhouse gases from burning fossil fuels. Soil disturbance causes decomposition of organic matter which emits carbon back into the atmosphere (Almaraz et al. 2009).

O6: (2) soil disturbance will create dust particles.

R6: (1) there is no habitat on highly disturbed soils.

S6: (3) by disturbing the soil, conventional tillage inhibits the establishment of invasive species

C7: (4) reduced soil disturbance allows the formation of soil aggregates and organic matter which improve its structure and reduces vulnerability to erosion.

D7: (4) according to Chen et al. (2000), conservation or reduced tillage results in much less runoff than conventional tillage, and less runoff than no till.

E7: (4) less soil disturbance results in a reduced loss of soil due to tillage

I7: (4) sediment loss of N is greatly reduced under reduced till management (Chen et al. 2000).

J7: (5) sediment losses of P are greatly reduced by reduced tillage (Chen et al. 2000), thereby reducing contamination of waterways.

K7: (3) pesticide use generally increases with no-till (Lobb et al. 2007). An increase in pesticides increases the risk of contamination of water, but the soil structure improvements gained by no-till may reduce leaching of pesticides, so there is an impact but it is generally benign.

L7: (4) pathogens behave similarly to phosphorus in the soil, therefore same scoring

M7: (4) sediment losses are sharply reduced with reduced tillage (Chen et al. 2000).

Residues left on the surface under conservation tillage regimes retain soil structure and therefore result in less sedimentation of waterways (Tong and Naramngam 2007).

R7: (3) a low level of soil disturbance may provide some habitat for species, however it is a temporary situation and is dependent on the crop type. It may or may not provide benefits.

C8: (5) wind erosion is reduced under no-till as residues left on the ground reduce the amount of soil lost.

D8: (5) surface runoff is found to be reduced by 11-50% under no till compared to conventional tillage (Tong and Naramngam 2007). According to Chen et al. 2000 no till increased runoff more than reduced till (conservation tillage) but remained below conservation tillage.

E8: (5) no till results in minimal disturbance of the soil therefore negligible tillage erosion.

I8: (5) N is primarily lost through infiltration and leaching to groundwater. No till improves soil structure, nutrient retention, soil organic matter and infiltration (Constantin et al. 2010). According to Tong and Naramngam (2007), more soil N is retained under no-till - therefore less is lost to infiltration (than conventional till).

J8: (5) P loss from fields is primarily through surface runoff (Tong and Naramngam 2007). Sediment losses of P are greatly reduced by reduced tillage (Chen et al, 2000), thereby reducing contamination.

K8: (3) pesticide use generally increases with no-till (Lobb et al. 2007). An increase in pesticides increases the risk of contamination of water, but the soil structure improvements gained by no-till may reduce leaching of pesticides. There is an impact but it is generally benign.

L8: (5) pathogens behave similarly to phosphorus in the soil, therefore same scoring.

M8: (4) sediment losses are sharply reduced under reduced tillage regimes (Chen et al. 2000). Residues left on the surface under no till retain soil structure and therefore result in less sedimentation of waterways (Tong and Naramngam 2007).

N8: (4) In wet conditions no-till can cause soil organisms to emit N_20, however this is largely offset by carbon sequestered by residues, improved productivity and soil carbon formation resulting from no-till (Constantin et al. 2010, Blanco-Canqui and Lal 2009).

R8: (4) minimal soil disturbance may provide shelter and habitat for species.

I10: (3) Tong and Naramngam (2007) provides a reference for this, especially if a legume is included in the rotation.

J10: (4) crop rotation influences the amount of P in the soil. Rotations decrease P loads relative to continuous cropping (Tong and Naramngam 2007).

K10: (4) crop rotations can be beneficial for breaking pest cycles, therefore pesticide application can be reduced (Chen et al. 2009). With a reduction in pesticide application comes a reduce risk of contamination of water by pesticides.

M10: (4) Tong and Naramngam (2007) reported that sediment load under crop rotations were reduced compared to continuous cropping.

N10: (4) continual cover from crop rotation will continue to sequester carbon in the soil, and improve soil structure which also sequesters carbon.

S10: (5) crop rotations can provide an effective weed control function, matched only by chemical weeding (Caporali and Onnis, 1992)

B14: (4) it is a good practice to leave crop residues on ground, however the residues must be spread evenly in order for proper planting to occur (Blanco-Canqui and Lal 2009, Alberta Agriculture 2004b)

C14: (5) according to Lobb et al. (2007), crop residues protect soil surface from the erosive forces of wind.

D14: (5) according to Lobb et al. (2007), crop residues absorb the impact of raindrops and slow surface water movement on the crop surface, thereby reducing runoff erosion.

F14: (4) residues left on ground decompose slowly and improve soil organic carbon over time. As well, the protection it provides against wind and water erosion improves soil organic matter over time (Skidmore et al. 1986).

G14: (4) residues left on ground slow evaporation and therefore reduce risk of leaving salts behind causing saline soils. (Steppuhn 2006, Alberta Agriculture 2004b)

I14: (4) crop residue cover will reduce surface water runoff, reducing nitrogen transport to surface waters, however residues may improve infiltration, which poses risk of nitrogen contamination of groundwater.

J14: (5) crop residues slow and reduce surface runoff and therefore reduce risk of transport of P to surface waters.

M14: (4) reduction in erosion by wind and water results in less sediments leaving the crop and entering into surface water.

N14: (3) according to Lobb et al. (2007) crop residues left on the soil surface reduce the exchange between water, energy and greenhouse gases with the atmosphere.

O14: (4) crop residues cover the surface of the soil, thereby reducing risk of wind erosion and generation of primary particulate matter (dust).

R14: (4) crop residues provide food and shelter for wildlife (Lobb et al. 2007).

S14: (4) residues left on ground will inhibit the germination of invasive species - it will "smother" them out (Blanco-Canqui and Lal, 2009).

C15: (5) residues left on ground will reduce wind erosion by protecting the soil surface.

F15: (5) residues left on ground decompose slowly and improve soil organic carbon over time. As well, the protection it provides against wind and water erosion improves soil organic matter over time (Skidmore et al, 1986).

G15: (5) crop residues left or spread on the surface can slow evaporation and reduce the risk of salts being left behind, causing soil salinity.

I15: (4) crop residue cover will reduce surface water runoff, reducing nitrogen transport to surface waters, however residues may improve infiltration, which poses risk of nitrogen contamination of groundwater (Blanco-Canqui and Lal, 2009)

J15: (5) crop residues reduce surface runoff and therefore reduce risk of transport of P to surface waters.

M15: (4) reduction in erosion by wind and water results in less sediments leaving the crop and entering into surface water.

S15: (5) residues left on ground will inhibit the germination of invasive species - it will "smother" them out.

B17: (3) While removing crop residue reduces residue cover, in many cases if there is enough residue to warrant baling, there will still be enough unbaled stubble and residue to prevent erosion. So increased erosion related risks may not be large (D. Haak, personal communication). Campbell et al. (1991) have shown that baling residue does not reduce soil carbon, since much carbon input comes from root and stubble. Baling excess residue may facilitate no till and also reduce residue borne diseases which may result in less pesticide use. The net impact is neutral

C17: (1) removing residues from surface exposes soil and increases risk of erosion by wind.

D17: (1) removing residues from surface exposes soil and increases risk of erosion by water.

F17: (1) removing residues from the soil surface prevents any from being incorporated into the soil organic matter.

G17: (1) removing residues from the soil surface results in evaporation of soil moisture, increasing risk of leaving salts behind (W. Eilers, personal communication).

I17: (1) no residues on the ground results in increased erosion from wind and water, therefore an increased risk of nitrogen transport to surface waters.

J17: (1) no residues on the ground results in increased erosion from wind and water, therefore an increased risk of phosphorus transport to surface waters.

M17: (1) no residues on the ground results in increased erosion from wind and water, therefore an increased risk of sediment transport to surface waters.

O17: (1) increased risk of particulate matter due to increased risk of erosion and activities associated with baling.

S17: (2) increased risk of invasive species since there is no residue cover to inhibit establishment.

C18: (1) removing residues from surface exposes soil and increases risk of erosion by wind.

D18: (1) removing residues from surface exposes soil and increases risk of erosion by water.

F18: (1) removing residues from the soil surface prevents any from being incorporated into the soil organic matter.

M18: (1) reduced surface cover by residues leads to more erosion and therefore sedimentation into waterways.

N18: (1) burning crop residues emits carbon dioxide which is a greenhouse gas (Alberta Agriculture 2004b).

O18: (1) particulates emitted by burning.

B19: (1) this is essentially the same practice as conventional tillage so should be given the same rating (D. Haak, personal communication).

C19: (1) incorporating residues leaves soil surface bare, therefore making it vulnerable to erosion by wind.

D19: (1) incorporating residues leaves soil surface bare, therefore making it vulnerable to erosion by water.

E19: (2) tillage operation required to incorporate residues into the soil increase risk of erosion by tillage

F19: (4) incorporation of crop residues often increases the organic matter content of the soil. Compared to leaving residues on the surface, this benefit is short-lived (Skidmore et al, 1986).

I19: (2) increased risk of erosion by wind, water and tillage may lead to surface water runoff and contamination of water by N

J19: (2) increased risk of erosion by wind, water and tillage may lead to surface water runoff and contamination of water by P

M19: (2) increased risk of erosion by wind, water and tillage may result in sediments entering into waterways. However, the added organic matter to the soil may improve soil structure, thereby reducing vulnerability to erosion.

B20: (3) same comment as for baling.

M20: (1) despite composting, this implies that the residues have been taken off the surface, and therefore leaves the soil more vulnerable to erosion and transport to waterways.

B21: (4) Chaff is a very small portion of residue, so the residue removal impact is non existent. Chaff contains weeds seeds, so removal of chaff will result in less herbicide use (D. Haak, personal communication).

B22: (3) There may be some erosion related risks associated with overgrazing residues. However, cattle will usually glean vegetative and grain related residue, rather than coarse straw. The latter, which is more important for erosion control will remain in most cases.

Grazing residues is one method of extending the grazing season which provides GHG benefits associated with not having to haul feed and spread manure from confined livestock pens. Furthermore, direct deposition of manure by cattle on the landscape can result is much more efficient utilization of nitrogen by subsequent crops, resulting in improved crop growth and potential improvement in soil carbon in the long term (D. Haak, personal communication).

C22: (2) soil disturbance from grazing livestock can make the soil vulnerable to erosion by wind.

D22: (2) soil disturbance from grazing livestock can make the soil vulnerable to erosion by water.

G22: (3) increased risk of salts introduced into the soil from manure added by grazing livestock.

I22: (2) grazing on residues by livestock will lead to manure being spread on the surface of the soil and not incorporated - increasing the risk of surface runoff into waterways.

L22: (1) grazing livestock will deposit manure directly on the field. Runoff of this manure may lead to pathogen contamination.

B25: (5) USEPA 2001.

I25: (5) applying fertilzer with seed allows for optimal nutrient uptake from the plant, therefore less risk of excess nutrient movement into surface or groundwater.

B26: (4) less efficient than applying with seed because of slight mixing in soil profile and greater time lag between fertilizer application and seeding operation (D. Haak, personal communication)

B28: (4) Nutrient management-wise this is efficient and usually related to nutrient intensive crops (e.g. potatoes) and is similar to foliar applications (J. Hewitt, personal communication). More efficient nutrient utilization because delayed application allows for better matching with requirement based on growing conditions. In most cases nutrients injected so negligible losses (D. Haak, personal communication)

I28: (3) applying fertilizer on the surface increases risk of surface runoff and contamination of water, and doesn't necessarily optimize nutrient uptake by plant.

J28: (3) P is not readily soluble therefore applying on the surface does not make it readily available to crops. This increases the potential for the nutrient to be transported by surface runoff into water.

E30: (2) in a managed landscape 'no risk' is not possible, however any tillage operation that turns over the soil puts soil at risk of tillage erosion.

J30: (3) this practice may not be economically optimal as the P may not be readily targeted to plant roots where they need it and may bind to soil particles, making it unavailable to crops. It is less likely to be transported by leaching therefore there is not a high risk of contamination of water.

B31: (3) when used correctly, this method can optimize nutrient uptake by orchard trees. (Neilsen and Neilsen 2002).

D31: (3) water improperly applied to the crops could lead to runoff and erosion.

B32: (3) plants leaves have barriers to absorption such as wax or hair, however under some conditions (soil pH and compaction) foliar application of fertilizers and micronutrients may be the most effective method of application. (Fageria et al. 2009)

I35: (0) annual soil testing provides information to producers so appropriate levels of nutrients can be applied to soil for optimal crop growth by reducing the risk of applying excess nutrients. However, soil nutrient testing does not directly impact water contamination by N since it does not guarantee that the producer will apply nutrients based on the results of the testing, therefore a score is not assigned.

N35: (0) applying N based on precise estimation of plant needs will reduce N_2O emissions (Smith et al. 2008). Soil testing can identify the existing N levels in the soil, allowing for a more precise application. However, since this is not a direct linkage (i.e producers have to act appropriately based on results of soil testing), no score is assigned.

I36: (0) soil testing every 2-3 years helps optimize soil N levels. Reducing excess soil N reduces risk of contamination of water. However, since this is not a direct linkage (i.e producers have to act appropriately based on results of soil testing), no score is assigned.

N36: (0) applying N based on precise estimation of plant needs will reduce N2O emissions (Smith et al. 2008). Soil testing can identify the existing N levels in the soil, allowing for a more precise application. However, since this is not a direct linkage (i.e producers have to act appropriately based on results of soil testing), no score is assigned.

I37: (0) while soil testing is a good practice, N levels can change annually depending on inputs, climate and crop grown, therefore every 4-5 years is not sufficient to reduce risk of contamination of water by N. However, since this is not a direct linkage (i.e producers have to act appropriately based on results of soil testing), no score is assigned.

N37: (0) reduce N2O emissions (Smith et al. 2008). Soil testing can identify the existing N levels in the soil, allowing for a more precise application. However, since this is not a direct linkage (i.e producers have to act appropriately based on results of soil testing), no score is assigned.

N42: (4) applying nutrients only to meet plant needs reduces the risk of emissions of N_2O (Smith et al. 2008).

N43: (1) excess N in wet soil can produce N_20, a powerful greenhouse gas. Not reducing fertilizer to compensate for manure application can result in excess soil nutrients and therefore more greenhouse gases (Smith et al. 2008).

F45: (0) timing of fertilizer is optimal for availability to plants therefore plant mass should be adequate and should contribute to SOM. N fertilizers may not contribute to increase of SOM however (Khan et al. 2007). Since this is not a direct linkage (i.e producers have to act appropriately based on results of soil testing) however, no score is assigned.

I45: (5) this is optimal timing to maximize crop uptake of the nutrient and reduce excess soil nutrients which may be transported to waters.

N45: (5) nutrients should be applied for optimal plant uptake so excess nutrients do not remain in the soil for long periods of time, increasing the risk of GHG emissions and runoff (Smith et al. 2008).

I46: (3) this practice does not allow for optimal nutrient uptake by crops and therefore may result in excess nutrients being transported and contaminating water.

I50: (0) being unaware of the nutrient content of manure increases the risk of over-application of nutrients and excess nutrient runoff or leaching and contaminating water. However, since this is not a direct linkage (i.e producers have to act appropriately based on results of soil testing), no score is assigned.

F53: (0) soil organic carbon may increase due to solid manure application before crop growth. This timing is optimal for crop to maximize nutrient uptake and therefore produce a large yield, which can positively influence soil organic carbon. However, since this is not a direct linkage (i.e it assumes that crop growth will be strong based on nutrients alone), no score is assigned.

I53: (5) optimal timing of manure application allows nutrients to be available to plants when their demand is the greatest, therefore reducing chances of leaving excess N in the soil, and having it leach into groundwater. (Alberta Agriculture 2004b)

N53: (0) this may contribute to greenhouse gas emissions if soils are wet and N_20 is produced from excess nutrients in the soil. However, applying when plants have greatest uptake reduces the time excess nutrients are in the soil and therefore reduces risk of N_2O emission (Smith et al. 2008). Since this is not a direct linkage, no score is assigned.

F54: (0) this practice may make nutrients available to crops after growth has began, increasing yields and therefore soil organic matter. However, since this is not a direct linkage (i.e it assumes that crop growth will be strong based on nutrient application alone), no score is assigned.

B59: (5) agricultural activities hold an inherent risk to the environment, therefore some risk is acceptable. This practice is the best possible practice therefore considered very low risk.

E59: (2) the tillage operation required to incorporate the manure into the soil may result in erosion.

F59: (4) soil organic carbon may be increased by incorporating manure into the soil, providing organic material and available nutrients to the growing crop increasing yield.

I59: (5) incorporating manure after spreading conserves nutrients and makes them less vulnerable to runoff (Gilley et al. 2008).

J59: (5) incorporating manure after spreading conserves nutrients and makes them less vulnerable to runoff (Gilley et al. 2008).

L59: (1) assuming pathogens are contained in manure, incorporation of manure does not necessarily kill the pathogens (Hutchison et al. 2004).

P59: (5) zero risk is not possible and some ammonia will be emitted as a result of manure management, however this is the best possible practice to apply solid manure and reduce ammonia emissions (S. Bittman, personal communication).

Q59: (5) while risk of odour is inherent in manure management, this is the best practice possible to minimize odour (D. Masse, personal communication).

L60: (3) Hutchison et al. (2004) found that leaving manure containing pathogens on the surface of the soil for 5 days will kill all pathogens from ultraviolet light from the sun. However, there is heightened risk of runoff and water contamination as well as other nutrient loss by leaving it on the soil surface.

Q60: (1) not incorporating manure leads to odour episodes that could have been minimized through other practices (D. Masse, personal communication).

E63: (2) the tillage operation required to incorporate the manure into the soil may result in erosion.

I63: (5) because no risk is not possible and because this practice reduces risk of water contamination by N, this practice is considered the most optimal practice, making the N readily available for plants and reducing its chance of surface runoff or groundwater leaching.

J63: (5) incorporation of manure has been associated with decreased levels of reactive phosphorus in surface runoff (Volf et al. 2007)

L63: (1) according to Hutchison et al. (2004), pathogens remain viable for a longer period of time when manure is immediately incorporated into the soil than when it is left on the surface. However it is likely that the other benefits of this practice will outweigh the drawbacks

S63: (5) immediate incorporation of solid manure reduces odour nuisance (D. Masse, personal communication)

E64: (2) the tillage operation required to incorporate the manure into the soil may result in erosion.

E65: (2) the tillage operation required to incorporate the manure into the soil may result in erosion.

I65: (3) incorporating manure is a positive practice, however after 2 days the risks of nutrient loss through volatilization and surface runoff are increased (Alberta Agriculture 2004)

P65: (2) ammonia loss occurs immediately after manure spreading and over 50% of the nutrients are lost after 3 days (S. Bittman, personal communication).

E66: (2) the tillage operation required to incorporate the manure into the soil may result in erosion.

N69: (0) understanding nutrient content of manure reduces risk of overapplying nutrients, and reduces risk of N2O emission (Smith et al. 2008). However since there is no direct impact (i.e. based on assumptions that producers will act based on results of testing), no score is assigned.

P73: (4) optimal timing of manure avoids delays between nutrient application and plant uptake to reduce risk of N_2O emission (Smith et al. 2008).

D83: (2) increased liquid on the land could lead to surface runoff and therefore erosion by water (liquid manure).

E86: (2) the tillage operation required to incorporate the manure into the soil may result in erosion.

I120: (5) maintaining a continuous plant cover allows nutrients to be used by plants and therefore reduces risk of leaching or surface runoff.

G129: (5) leaving a soil bare promotes evaporation and salt accumulation. Continuous cropping mitigates this risk (Saskatchewan Agriculture 2008).

I129: (4) cover crops were found to reduce surface N runoff and contamination by infiltration (Parkin et al. 2006).

G130: (5) winter cover crops use up soil moisture thereby lowering the water table that can inhibit salinization (W. Eilers, personal communication).

I130: (5) seeding winter cover crop uses excess N from the soil, thereby reducing the likelihood of N leaching over the winter. Crop residues from the winter crop provide SOM and N available for the next crop, thereby potentially reducing the amount of N inputs needed (Wyland et al. 1996).

N130: (4) cover cropping could possibly lead to denitrification after residues from cover cropping are incorporated, however this is outweighed by the benefits of cover cropping. Conversely, the N used by the cover crop can reduce the potential for denitrification of residual soil nitrogen in soil prior to planting cover crop. (Wyland et al. 1996),

R130: (5) according to Alberta Agriculture (2004b), planting winter cereal crops increases habitat availability.

N134: (5) permanent perennial forages sequester carbon and provide long term storage (Smith et al. 2008)

I135: (3) straw mulching helps retain nutrients such as N, helps retains soil moisture, and improves infiltration, which may increase the risk of N leaching (Blanco-Canqui and Lal, 2009).

J135: (3) reduced water erosion reduces the likelihood that P will be transported into waterways (van Bochove et al. 2007)

G138: (3) drainage lowers the water table, increasing the distance water must travel in order to evaporate, however drainage of saline soils means the salt gets transported somewhere else (W. Eilers, personal communication).

I138: (2) tile drainage improves the structure of very wet soils, therefore allowing more organic matter to be formed. However, tile drainage allows easy transport of dissolved N into tiles and into waterways. (De Jong et al. 2009).

N138: (0) fields with drainage can increase productivity, thereby capturing more CO_2 and sequestering more carbon. Also, well drained soils have less likelihood of producing N_2O by having improved aeration (Smith et al. 2008). However, these impacts are indirect, so no score is assigned.

B215: (5) Alberta environmental manual for crop producers (2004b) lists this as the #1 practice to dispose of pesticides.

B216: (5) Alberta agriculture environmental manual for crop producers (2004b) lists this as the #2 practice for disposing of pesticides.

P269: (1) anaerobic decomposition of organic matter in liquid livestock manures, most notably stored in lagoons or tanks emits CH_4 and contributes to GHG emissions (van der Meer 2008).

N281: (5) covering slurry storage reduces emissions of greenhouse gases and NH_3. (Chadwick 2005).

P281: (5) slurry covers reduce emissions of NH_3 and other greenhouse gases (Chadwick, 2005).

R284: (4) reduces NH_3 emissions (S. Bittman, personal communication).

B285: (3) can reduce NH3 emissions however if it sinks, it becomes ineffective (S. Bittman, D. Haak, personal communication).

B290: (5) steel must be treated to not corrode from the manure. Corrosion will result in leakage and likely contamination (D. Haak, personal communication).

N302: (3) aerating manure can reduce CH_4 emissions (Pattey et al. 2005).

P306: (4) composting under aerobic conditions can reduce CH_4 emissions (Pattey et al. 2005).

N325: (4) Chadwick (2005) found that and N_2O emissions were reduced when covered. CH_4 was reduced in some cases, however increased in others.

O325: (5) covering manure reduces dust and other particulates from being emitted.

P325: (5) Chadwick (2005) found reductions in NH_3 emissions of up to 80-90% when manure piles were covered however the same result was found during persistent rainfall.

N357: (3) composting solid manure can lead to anaerobic decomposition which emits CH_4 (van der Meer, 2008). However, under aerobic conditions CH_4 emissions were shown to be significantly reduced by Pattey et al (2005).

I377: (4) forages that grow in early spring will use N in the soil therefore reducing N available to leach through soil.

J377: (0) forages that grow in early spring will use P in the soil, therefore reducing the amount vulnerable to runoff

B382: (2) keeping cattle on the landscape for a longer period has an overall benefit as it helps to increase nutrient efficiency of manure (D. Haak, personal communication).

S384: (5) properly grazing several different sites inhibits the growth of weeds and prevents establishment of invasive species (Alberta Agriculture 2004b).

B385: (4) moving watering sites is not as beneficial as moving feed and shelter, because cattle do not need to water as often, can walk greater distances to water sources, and in many cases can eat snow as a water source (D. Haak, personal communication).

N386: (5) bedding material can emit large amounts of greenhouse gas. Moving the bedding sites will reduce the amount of gas emitted (Alberta Agriculture 2002b)

B387: (1) moving cattle around a pasture is the best practice to distribute nutrients and reduce risk of overgrazing and erosion (Alberta Agriculture 2002b).

R387: (1) rotational grazing allows resting pastures to be used for other wildlife habitat. A limited amount of pasture means less habitat availability for other species (Alberta Agriculture 2004)

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APPENDIX 5: LIST OF AGRICULTURE AND AGRI-FOOD CANADA TECHNICAL EXPERTS USED FOR CONSULTATION

The following is a list of AAFC research scientists and technical experts who provided input on the practice rankings found in Table 3.

Dr. Shabtai Bittman

Research Scientist, Environmental Health, Agriculture and Agri-Food Canada

Leslie Cass

Manager, Pesticide Risk Reduction, Agriculture and Agri-Food Canada

Dr. Craig Drury

Soil Biochemist, Environmental Health, Agriculture and Agri-Food Canada

Warren Eilers

Senior Land Resource Officer, Land Resources, Agriculture and Agri-Food Canada

Dennis Haak

Senior Soil Resource Specialist, Soil Resources Unit, Agriculture and Agri-Food Canada

Jamie Hewitt

Senior Environmental Analyst, Policy Research Division, Agriculture and Agri-Food Canada

Dr. Ted Huffman

Research Scientist, Environmental Health, Agriculture and Agri-Food Canada

Tim MacDonald

Officer, Pesticide Risk Reduction Program, Agriculture and Agri-Food Canada

Dr. Daniel Masse

Research Scientist, Environmental Health, Agriculture and Agri-Food Canada

Dr. Elizabeth Pattey

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Dr. Georges Theriault

Biologist in Soil Biochemistry, Environmental Health, Agriculture and Agri-Food Canada

Devon Worth

Technician, Environmental Health, Agriculture and Agri-Food Canada