Research Gaps and Next Steps in Manure Management Research

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Science to Social Issues

Contents

1 Introduction

The gaps and recommendations presented in this chapter resulted from discussions, gap analysis and project evaluation by the authors and others. The methods used are described in Chapter 1.

2 Industry Challenges Related to Manure Management

At a workshop in Banff in March 2003, which brought together agricultural specialists, professionals and industry representatives, participants discussed the challenges and needs facing the agriculture industry with respect to manure management. These discussions contributed to the assessment of the gaps and the development of recommendations for next steps for this project.

The challenges and needs identified at the workshop were:

Farm management

- Producers are overwhelmed with requirements such as considerations related to the health and productivity of their livestock and crops, financial issues, environmental issues, regulatory requirements, marketing issues and community issues.
- Producers do not always have good access to resources that aid in gathering, analysing and using information.
- Producers are facing a "paradigm shift" requiring a new understanding of their limitations and boundaries and an increased need to seek professional advice on managing their farm operations.

Extension

- Helping producers to make this paradigm shift may require development of training and certification processes for consultants, technicians and others required for a producer's technical support network.
- Extension agents need to continue to evaluate perceived barriers to adoption of beneficial management practices (e.g. economics, ease of operation) and to find more effective ways reduce these barriers.
- Producers need information on manure management that is packaged to meet their needs, emphasizing practical cost-effective methods.

Research

- Researchers need to come together to identify priorities (collaboration on a national and international level).
- Researchers need to determine what, if any, types of biosecurity hazards might be posed by manure management, if producers are taking the necessary precautions to prevent such hazards, and to develop plans to handle a biosecurity crisis if one should ever occur and the long-term implications for manure management.
- A nationally based integrated GIS system is needed.

Industry image

- There is a perception among the public that manure is being dumped without regard for the environment.
- A proactive communication strategy is needed to help change the public's image of the agricultural industry, including improving the public's understanding of the value of manure.
- Improving agriculture's image could require a substantial investment.

3 Gaps Identification and Prioritization

3.1 Gaps Identified at the Banff Workshop

While preparing the first draft of the literature review, the authors developed preliminary lists of research gaps for their sections, based on their assessment of the existing research. At the Banff workshop, the participants supplemented these preliminary lists of gaps.

The gaps identified at the Banff workshop are listed below. They were not ranked in any order.

Feed Management

- Determine the minimum dietary levels of nitrogen and phosphorus to maintain animal growth and production with minimum nitrogen and phosphorus excretions.
- Evaluate the effects of dietary nitrogen and phosphorus manipulation on nutrient composition in manure losses from agricultural landscapes.
- Determine how changes in animal physiology affect nutrient excretions.
- Determine the effectiveness and economics of different enzymes and additives in reducing nutrient excretions by animals.
- Develop new feeding technologies that minimize feed waste.
- Investigate the effectiveness of modifiers of digestion and/or fermentation to reduce methane emissions.
- Develop genetic and reproductive technologies that allow animals to use nutrients more efficiently.
- Reduce salt content, especially sodium, to minimize adverse effects on soil quality when manure is applied to land.
- Investigate the consequences of feeding heavy metals, and develop guidelines for restricting manure applications based on the levels of heavy metals in manure.
- Quantify how to deal with feed variability when developing nitrogen- and phosphorus-restricted rations.

Land Application and Handling of Manure

- Investigate the impact of different manure applications on nitrate leaching in different soils.
- Evaluate the effectiveness of set-backs to reduce or prevent nutrient and pathogen losses to water bodies.
- Investigate the effects of beneficial management practices (BMPs) on minimizing nitrogen and phosphorus losses from agricultural landscapes.
- Study the effect of manure injection in reducing nutrient losses and odour.
- Develop management tools to minimize phosphorus losses in watersheds.
- Conduct cost-benefit analyses of manure management BMPs.
- Evaluate the impact of fall-applied manure under Alberta conditions.
- Evaluate options for “mining” nutrients from manured fields using plant and other biological reclamation strategies.
- Investigate methods to control soluble phosphorus losses where manure is surface-applied (forage, pasture).
- Evaluate alternative uses of manure.
- Develop techniques to assess the dynamics of nutrient availability from different types of manure in specific soil-cropping-climate systems.
- Evaluate the cost-benefits of manure storage systems that conserve nutrients.
- Continue to investigate, develop and communicate cost-effective options to minimize odour from land applications of manure.
- Encourage producers to use a systems approach for management of manure constituents.
- Investigate preferential flow and hydrological considerations in nutrient movement.
- Investigate emerging issues and opportunities such as metals in manure, pharmaceuticals, and endocrine disruption.
- Monitor environmental impacts of specific BMPs under specific conditions to more accurately predict their benefits when applied on individual farms.
- Investigate and develop options for environmentally safe winter applications of manure.

Zoonotic Pathogens

- Investigate pathogen persistence on the farm and determine if the farm is a gateway through which the microbes pass.
- Investigate how bacteria move from one animal to another.
- Develop methods for rapid testing of very low levels of *Campylobacter, Salmonella, Toxoplasma, Vibrio, E. coli* O157:H7, *Cyclospora, Cryptosporidium parvum*, and viruses in manures, soils and composts.
- Develop management practices and treatment technologies to prevent pathogen contamination while handling, storing and applying animal manure and by-products.
- Determine how BMPs affect pathogen survival and transport.
- Investigate the generation and proliferation of bio-aerosols.
- Determine the risk posed to human health from manure pathogens.
- Determine the survival and persistence of manure pathogens in groundwater and surface water in the natural environment.
- Develop options for producers to use a holistic approach to managing pathogens in relation to other contaminants of concern.
- Determine the effects of existing manure handling and management practices (e.g. short-term stockpiling) on pathogen transport and viability.
- Develop the information needed to conduct reliable risk assessments of the hazards that manure pathogens pose for human and animal health, and conduct risk assessments.
- Determine whether or not manure pathogens can survive aerosol transmission (attached to dust particles) and, if so, whether they could be a health concern.
- Determine the risk of the transmission of resistance from antibiotic-resistant bacteria in manure to other bacteria.
- Determine the level of occurrence of antibiotic-resistant bacteria in the environment, whether manure applications on land are contributing to the presence of these bacteria in the environment, and whether these bacteria pose a health risk for humans and animals.

Odour

- Investigate and determine acceptable odour exposure for humans in terms of frequency, intensity and duration.
- Establish standards for measuring odour hedonic tone.
- Investigate electronic nose technology as an alternative means of quantifying odour intensity and character.
- Establish a relevant standard for evaluating odour control technology in which perceived intensity is considered.
- Establish a method of determining the distance from a confined feeding operation (CFO) at which the health risk becomes unreasonable.
- Focus research and extension activities on odour reduction at growing/finishing facilities, where the most feed is consumed and the most manure is generated.
- Generate odour data that are lacking for the following:
    - liquid manure storage, relative to separated, non-separated, and agitated storage
    - solid manure storage, relative to temperature, moisture content and differences among dairy, beef, poultry, and swine manure
    - indoor storage, relative to odour contribution from slats, solid floor and storage
    - ventilated vs. unventilated pit storage
    - alternative protein- and sulfur-reduced diets
    - straw and impermeable covers for manure lagoon storage
- Develop widely accepted protocols to measure odour emission rates from liquid surfaces and from irregularly shaped manure surfaces.
- Establish "typical" emission rates from various types of CFOs.

- Determine the variance estimates for calculation of the minimum distance separation (MDS) based on implementation of various BMPs.
- Assess the odour reduction ability and costs of manure pit additives under Alberta conditions.
- Develop variance estimates to MDS.
- Develop a nationally coordinated approach to research on odour.
- Developed standardized technology evaluation protocols.
- Develop alternative services for environmental consulting for farmers such as Enviro Clubs, consulting coalitions, and retainer-based consulting fees.
- Establish uniform provincial odour/siting regulations to allow responsible, economic and accepted livestock industry expansion.
- Develop standardized odour evaluation techniques to promote opportunities for data sharing and collaborative research.
- Develop standardized odour dispersion modeling for agricultural odour and gas emissions to promote uniform, comparable output from odour research so that data and information could be shared.
- Develop a widely accepted separation distance/siting method based on science to minimize and resolve conflicts over siting of livestock operations.
- Increase extension to producers on odour management, measurement and separation distance theory so they can communicate more effectively with neighbours about impacts of developments and expansions.
- Identify an odour “surrogate” or “tracer compound” to improve measurement and modeling of odour.
- Further investigate the effectiveness of different odour abatement and treatment methods to allow quantitative reduction of separation distance requirements.
- Establish regulations to reflect the state of the science in odour measurement, modeling and abatement technologies. These regulations need to be written in a format that is as flexible as possible so change can be made as technology and extension efforts develop and affect the industry and society.

Ammonia and Hydrogen Sulfide

- Develop and evaluate highly sensitive and more accurate standardized methodologies for emission concentration measurement to provide data for comparison with modeled results.
- Improve and validate existing models for gas emissions, transport and deposition.
- Evaluate existing emissions control technologies:
    - Improve and assess the multiple functions and uses of these technologies.
    - Develop a ranking system for comparison between different abatement technologies.
    - Develop better knowledge of the interaction between different emission control methods for different gases.
    - Develop an economic model to assess each emission control technology for costs and benefits. These models can be used to study the impacts of the technologies on production cost and return.
- Develop potential relationships between emissions constituents, concentrations and potential health indicators.
- Determine cumulative impacts of livestock operations located in the same area.
- Evaluate BMPs to assess their effects on ammonia and hydrogen sulfide emissions.
- Determine typical emissions from various types of CFOs.

Greenhouse Gases

- Investigate the basic processes involved in the creation of methane and nitrous oxide and the complex relationships among soil, air, water, animals and plants.
- Determine the processes responsible for nitrous oxide emission to gain a better understanding of the dynamic processes involved in nitrification and denitrification.

- Evaluate emissions coefficients for emissions due to mitigation practices for animals, livestock buildings and manure application on land.
- Develop a database on energy inputs for value-added products from manure.
- Collect data and establish a database with information on land availability for bio-energy and bio-materials.
- Develop models and gather spatial databases that would incorporate parameters such as climate, soils, land use and management (including manure applications).
- Improve methods to determine the relative contributions of the stages of livestock production and manure management.
- Collect data and standardize methodology for measuring field emissions and point source emissions (buildings and lagoons).
- Develop a better understanding of carbon dioxide, carbon budgets, and interrelationships between carbon dioxide and other greenhouse gases.
- Take a coordinated, cooperative approach to measuring and modeling air emission (ammonia hydrogen sulfide, greenhouse gases, bio-aerosols, etc.) to save time and money.
- Use a systems approach in quantifying overall and peak emissions from manure holding systems, and then develop engineering and BMP options to minimize emissions.
- Work with industry to target funding available for environmentally sustainable agriculture activities through the federal-provincial Agriculture Policy Framework.

Social Issues

- Identify the real reasons for conflicts related to manure management and livestock operations in Alberta.
- Investigate the methods that value the image of the industry.
- Investigate how the industry can be proactive in dealing with conflict.
- Identify potential areas of conflict and how they can be approached.
- Identify BMPs and technologies that have a high impact on the image of the industry.
- Continue to educate producers and the general public on conflict management methods, to help build communication and mutual understanding between producers and the public.
- Identify policy and regulatory options that could reduce conflicts.
- Use a collaborative, multidisciplinary approach with scientists, social scientists, government staff, and industry representatives to develop a strategy to address the gaps and issues.
- Identify producer interests, needs and concerns with respect to reluctance to shift attitudes about ways of doing business.
- Determine existing policies that are barriers to changing attitudes and ways of doing business.
- Investigate and find ways to resolve producer vs. producer conflicts.
- Describe a political process that is expected to develop when technology and regulations are proposed for manure management.
- Encourage more producers to become involved in making change happen in the political sphere.

3.2 Gaps Prioritization: First Phase

Each author identified four priority gaps for his or her section from the preliminary list of gaps and the gaps identified at the Banff workshop. (The gaps for nutrient management policies and programs were not included in the prioritization process.)

Feed Management

- Lack of basic understanding of the factors affecting dry matter intake and the relationship between feed intake and feed quality to manure production.
- Lack of detailed knowledge on amino acid and phosphorus requirements of ruminants.
- Lack of knowledge on the effects of genetics and implants on nitrogen and phosphorus excretion.
- Lack of knowledge on the effects of ionophores on nitrogen and phosphorus excretions relative to the effects of ionophores on maintenance energy requirements.

Land Application and Handling of Manure

- Investigate and document the effects of manure application BMPs on minimizing nutrient losses from agricultural landscapes.
- Evaluate the effectiveness of set-backs and buffer zones on reducing nutrient and pathogen inputs to water bodies in watersheds.
- Develop techniques and strategies to assess the dynamics of manure nutrients, especially nutrient release, in different soil-cropping-climatic systems.
- Evaluate options for "mining" nutrients from manured fields using plant and other biological reclamation strategies.

Zoonotic Pathogens

- Develop methods for rapid testing of very low levels of *Campylobacter, Salmonella, Toxoplasma, Vibrio, E. coli* O157:H7, *Cyclospora, Cryptosporidium parvum,* and viruses in manures, soils and composts.
- Determine the survival and persistence of manure pathogens in groundwater and surface water in the natural environment.
- Determine the risk of the transmission of resistance from antibiotic-resistant bacteria in manure to other bacteria.
- Determine the level of occurrence of antibiotic-resistant bacteria in the environment, whether manure applications on land are contributing to the presence of these bacteria in the environment, and whether these bacteria pose a health risk for humans and animals.

Odour

- Investigate and determine acceptable odour exposure for humans in terms of frequency, intensity and duration.
- Investigate electronic nose technology as an alternative means of quantifying odour intensity and character.
- Establish a relevant standard for evaluating odour control technology in which perceived intensity is considered.
- Develop widely accepted protocols to measure odour emission rates from liquid surfaces and from irregularly shaped manure surfaces.

Ammonium and Hydrogen Sulfide Emissions

- Develop and validate models for calculation of ammonia and hydrogen sulfide emissions from housing, manure storage and treatment, and land application of manure for cattle operations in Alberta.
- Assess the health effects and impacts of ammonia and hydrogen sulfide on workers and residents living near CFOs.
- Determine if oil sprinkling techniques can consistently reduce ammonia and hydrogen sulfide emissions from swine facilities in Alberta.
- Develop effective technology transfer tools that help CFO producers to adopt appropriate and economically feasible ammonia and hydrogen sulfide control technologies (diet manipulation and manure storage).

Greenhouse Gas Emissions

- Conduct research on the basic processes involved in the creation of methane and nitrous oxide from management practices and the interactions among soils, crops, pastures and livestock (i.e. whole farm approach).
- Determine greenhouse gas emissions coefficients for currently promoted BMPs for animals, livestock buildings, and manure storage, handling and application.
- Develop cost-effective, practical technologies to manage manure for energy and value-added products.
- Improve methods to determine the relative contributions of greenhouse gas emissions by the stages of livestock production and manure management.

Social Issues

- Identify producer interests, needs and concerns regarding reluctance to modify their way of doing business and their attitudes.
- Identify reasons and resolutions for farmer-to-farmer conflict.
- Determine existing policies that are barriers to changing attitudes and ways of doing business.

3.3 Gaps Prioritization: Second Phase

At a workshop in Edmonton in August 2003, the authors reviewed the list of 24 gaps (not including the social issues gaps) generated by the first phase of prioritization. They found that some of the gaps overlapped. Therefore, they merged the overlapping gaps to create the following set of 15 gaps:

Land Application and Handling of Manure

- Investigate the effects of management practices on minimizing nutrient and greenhouse gas losses to the environment from animals, buildings, storage, handling and application.
- Determine the cost/benefit implications of producer adoption of nutrient management BMPs.

Feed Management

- Develop a basic understanding of the factors affecting dry matter intake, amino acid requirements and phosphorus requirements of ruminants, and the relationship of feed intake and quality to manure production, nutrient levels in manure, and odour/gas production.
- Determine the effects of genetic implants and ionophores on nitrogen and phosphorus excretion.
- Develop the reproductive physiology and technology needed to ensure an increase in the number of offspring born per heifer and cow.

Odour and Other Gaseous Emissions

- Develop widely accepted protocols to measure manure gas, odour and viable pathogen emission rates from liquid and solid manure and confined buildings and manure application.
- Establish a relevant standard for evaluating manure gas and odour control technology.
- Investigate and determine acceptable odour exposure for humans in terms of frequency, intensity and duration.
- Develop cost-effective, practical technologies to manage manure for energy and value-added products.
- Investigate the basic processes involved in the creation of methane and nitrous oxide from management practices and the interactions among soils, crops, pastures, and livestock (i.e. whole farm approach).

Human Health

- Determine the survival and persistence of manure pathogens in groundwater and surface water in the natural environment.
- Assess the health effects of ammonia and hydrogen sulfide on workers and residents living near CFOs.
- Develop effective decontamination protocols and products for removal of manure pathogens from agricultural operations and food processing facilities.
- Develop methods for rapid testing of very low levels of *Campylobacter, Salmonella, Toxoplasma, Vibrio, E. coli* O157:H7, *Cyclospora, Cryptosporidium parvum*, and viruses in manures, soils and composts.
- Determine the level of occurrence of antibiotic-resistant bacteria in the environment, whether manure applications on land are contributing to the presence of these bacteria in the environment, and whether these bacteria pose a health risk for humans and animals.

3.4 Gaps Prioritization: Third Phase

The next step in prioritizing the gaps at the Edmonton workshop was to determine the “critical few” gaps. The participants used the following criteria to rate the 15 gaps:

a. Is it a challenging issue for the industry?
rating scale of 1 to 9; 9 = if not solved, industry growth will be questionable

b. What is the cost/benefit of the project?
rating scale of 1 to 9; 9 = all costs of producing, delivering and adopting a technology are very low compared to the anticipated benefits to producers and consumers

c. How will the project contribute to the competitiveness of the industry?
rating scale of 1 to 9; 9 = will contribute significantly

d. How will the project contribute to the environmental sustainability of the industry?
rating scale of 1 to 9; 9 = will contribute significantly

e. Can we write a research proposal around the idea?
rating scale of 1 to 9; 9 = clear and very specific idea

The process resulted in eight top priority gaps.

During the prioritizing process, the team determined that addressing these gaps was part of developing an overall solution to the two major concerns in manure management: protecting human health and protecting the environment. From the team's perspective, addressing these two concerns requires a comprehensive approach to risk. The team also developed an overall statement of intent to reflect this need.

Overall Statement of Intent:

Develop a comprehensive approach for predicting risk through geomatics and geographic information systems (GIS) to ensure sustainability and enable optimal site selection to reduce environmental and human health risk.

Top Eight Gaps

The gaps are not listed in any specific order.

- Develop widely accepted protocols to measure emission rates of manure gas, odour and viable pathogens from liquid and solid manure, confined livestock buildings and manure application.
- Determine the survival and persistence of manure pathogens in groundwater, surface water and air in the natural environment.
- Establish a relevant standard for evaluating manure gas and odour control technology.
- Develop a basic understanding of the factors affecting dry matter intake, amino acid requirements and phosphorus requirements of ruminants, and the relationship of feed intake and quality to manure production, nutrient levels in manure and odour/gas production.
- Assess the health effects of ammonia and hydrogen sulfide on workers and residents living near confined feeding operations.
- Develop effective decontamination protocols and products for removal of manure pathogens from agricultural operations and food processing facilities.
- Develop methods for rapid testing of very low levels of *Campylobacter, Salmonella, Toxoplasma, Vibrio, E. coli* O157:H7, *Cyclospora, Cryptosporidium parvum,* and viruses in manure, soils, and composts.
- Investigate the effects of BMPs on minimizing nutrient and greenhouse gas releases and losses from animals, livestock buildings, and manure storage, handling and application.

4 Recommendations for this Project and Other Similar Projects

4.1 Proposed Project Management Model

Based on input during the Edmonton meeting and individual interviews with team members and others, the following project management model is recommended for open-ended, complex projects that involve authors from many agencies and disciplines.

Dedicated Project Manager/Facilitator

A dedicated project manager/facilitator who has experience and skills primarily in project management will be an asset for this kind of project. That individual can be selected from within any of the participating organizations or contracted privately based on reputation and experience.

Team Development

Team Development Retreat: A team development session should be considered for this project to complete the next steps (recommended below) and/or for other similar projects when they are established. The retreat would be used to establish the following items:

- *Why*: Set the project purpose, vision and mission.
- *What:* Clarify expectations and desired outcomes, including products to be produced, goals and measures to be achieved, and applicable timelines and deadlines.
- *How*: Establish processes, administration, budget, resources, problem solving, conflict management, communication, meeting frequency, contingency planning.

- *Who*: Define clients and stakeholders, select reviewers, decide on contractors (if applicable) and set team members' roles and responsibilities.

The results of this retreat should be put in a written document that could be used as the project/team charter and the basis for the project management plan.

Ongoing Team Building: Frequent face-to-face meetings in one- to two-day facilitated workshops will help keep the project on track and ensure that all team members understand, agree to and follow the necessary steps in the project.

Funder - Project Team Communication
For open-ended literature review projects, a detailed outline of what will be addressed in the literature search should be developed and agreed upon between project team and funding agency at an early stage of the project.

4.2 Next Steps for this Project

Document Gaps

This literature review brings together a tremendous amount of quality information on practices and technologies for manure/livestock management. This document is a first step to putting much-needed information into one single document.

Even with a 400-page document, the authors were unable to address all issues related to manure management. One option under consideration is national collaboration with other provinces to improve and update the document.

This document and future editions will provide valuable information for funding agencies, commodity groups, professionals and individuals.

Some topics that could be expanded in the next edition include:

- Manure storage and handling
- Feeding strategies for swine and poultry
- Odour emissions from cattle feedlot operations

Some topics that could be added in the next edition include:

- Cost/benefit of manure management practices and technologies.
- Health risks related to manure management.
- Social issues as they are affected by policies, market, and rural/urban changes.

Another important step in adding value to this document will be to repackage some parts of the document to create user-friendly factsheets, brochures, or news articles for producers and commodity groups.

Proposed Process to Identify and Address Priority Gaps

The participants at the Banff workshop made the following recommendations for a process to identify and address the research gaps in the future:

- Develop a collaborative strategy for a focused, comprehensive process to identify and prioritize information gaps relevant to manure management in Alberta. This strategy would include the following components:
  - Further investigate current manure management research to determine what research exists or is currently being conducted that is applicable to Alberta conditions and needs.
  - Determine all stakeholders' needs with respect to manure management.
  - Develop a process to identify which of the identified gaps have the highest priority.
- Develop a strategy to build and enhance relationships with other provinces to jointly address priority gaps.
- Develop a strategy for collaboration with other agencies at national and international levels to address priority gaps.

Updating, Upgrading and Disseminating this Report

At the Edmonton workshop, the following steps were recommended to ensure that this edition of the report is accurate, usable and trustworthy, and to upgrade and update future editions of the report:

- Share the research gaps and the gaps prioritization process with more reviewers (researchers, industry, and other involved stakeholders) to ensure that the process and the gaps are credible from many viewpoints.

- Conduct a critical review process that includes many reviewers to ensure the report is accurate and usable; the authors could take a lead role by sending the draft to their peers. Negotiate up front with the reviewers about how their review is to be used and with whom it will be shared. Provide reviewers with the final copy of the report along with reasons why some of their input was used or not used.
- Set up a process to compare the list of gaps in this report with the research underway two years from now, and revise the list of gaps at that time.
- Identify topics that have not been dealt with in the current draft of the report. Identify and contact researchers who have the expertise to conduct literature reviews of these topics.
- In cooperation with ALIDF, share the final product with other researchers and the industry to obtain feedback to improve future editions of the report.
- Determine who will be responsible for the ongoing process to improve and update the report. Establish a plan and timeline for this process.
- Set up a process to build networks and alliances to tackle the gaps.
- Package the information in this report in other ways (e.g. fact sheets, news articles) to suit the needs of individual producers and commodity groups.
- Consider making this report available online in a PDF format.

5 Conclusion

A great deal of research has been done in recent years on the many aspects of manure management. Research funding agencies, researchers, extension agents and the agricultural industry need to know the practical results of this research and what information gaps remain in order to speed up progress in developing cost-effective manure management practices that protect the environment and human health.

Therefore, the authors of each chapter in this report's literature review have sifted through hundreds of research publications in their subject area and then summarized the major results and identified key information gaps.

The gap analysis process has taken the results of the literature review an important step further. It has identified which particular gaps most need to be addressed to ensure that producers have the information they need for sustainable manure management. This step is crucial to assist research funding agencies in setting priorities that will make the best use of the funds available for agricultural research.

The report's recommendations for other similar projects provide guidance for other multi-disciplinary teams involved in open-ended, complex projects. The recommended process to identify and address information gaps provides a more comprehensive approach than was possible in this project. And the recommended next steps for this project will add significant value to the large body of information in this report.

Manure is a valuable resource for the agricultural industry. This report provides diverse, detailed information and recommendations that can contribute to making the most of manure and to maintaining an environmentally, socially and economically sustainable agricultural industry.