Acknowledgements

This document is supplementary to Canadian Water Network's synthesis document, *Key Questions of the Science on Agricultural Phosphorus Losses During Storm Events and Beneficial Management Practices*, which was revised in May 2018.

Canadian Water Network thanks the following groups and individuals for their input:

Sandra Cooke (Senior Water Quality Supervisor, Grand River Conservation Authority)

Stefan Larrass (Senior Policy Advisor, Ontario Pork)

Melisa Luymes (Coordinator, Ontario Soil Network and Principal Consultant, Headlands Ag-Enviro), and **farmers from the Ontario Soil Network**

Michael Keegan (Grow Ontario Together and Michael Keegan & Associates)

Keith Reid (Research Scientist, Agriculture and Agri-Food Canada; Co-author, *A Phosphorus Primer on Best Management Practices for Reducing Phosphorus from Agricultural Sources*)

McKenzie Smith (Audit Coordinator, Fertilizer Canada), and **members of the 4R Ontario Steering Committee**, including: Fertilizer Canada, Ontario Agri Business Association, Grain Farmers of Ontario, and International Plant Nutrition Institute

Chris Van Esbroeck (Farmer and OMAFRA nutrient management specialist)

This project was funded by the Ontario Ministry of Agriculture, Food and Rural Affairs.

Canadian Water Network is Canada's trusted broker of research insights for the water sector. When decision-makers ask, 'What does the science say about this?' we frame what is known and unknown in a way that usefully informs the choices being made.

Canadian Water Network

Contents

Introduction

With financial support from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), Canadian Water Network (CWN) undertook a project to summarize the state-of-the-knowledge on agricultural phosphorus (P) losses during extreme weather events in Ontario, with the goal of achieving better use of that collective knowledge to inform actions and investments aimed at reducing nutrient losses from agricultural lands.

This process involved an expert workshop and online questionnaire that gathered multiple perspectives from academia, conservation authorities, federal and provincial government representatives, and the agriculture industry in southwestern Ontario. Some experts from Western Canada and the United States were also invited to participate in the discussions.

In consultation with a technical advisory group, a synthesis document was drafted in March 2018 to convey key messages of the state-of-the-knowledge to OMAFRA. This document focused on high-level implications of leading science and practice for selecting and implementing P management options, including recommended approaches and next steps for the selection of beneficial management practices (BMPs).

During early discussions with the technical advisory group, a consensus emerged regarding the need to focus further work on clarifying the contribution of hydrologic events and transport pathways to better understand the ability of BMPs to reduce P losses from agricultural lands. The experts agreed that in order to characterize BMPs as successful and unsuccessful, the utility of the practices had to be determined in the context of site-specific considerations related to dominant transport conditions for a given farm/setting, as well as the likelihood of practical uptake and application by practitioners, rather than solely technical generalizations about overall "effectiveness" of individual BMPs. The experts indicated that the two biggest factors in determining which BMPs would be most effective were: recognizing the nature of the dominant ways phosphorus would likely be transported to receiving waters; and recognizing how reducing the risks from these pathways relate to the risks experienced by the farmer/practitioner. As a result, the synthesis document focused on recommended approaches to address these gaps in knowledge and next steps for OMAFRA.

In the spring of 2018, representatives from the agricultural community, and those who work closely with farmers, were asked to provide feedback on the recommended approaches. CWN consulted members of the Ontario Soil Network, 4R Ontario, the team that produced Ontario's Phosphorus Primer on Best Management Practices for Reducing Phosphorus from Agricultural Sources, OMAFRA staff, Grand River Conservation Authority, Grow Ontario Together and Ontario Pork for their insights on how the recommended approaches, if implemented, would play out "on the ground." Their aggregated input has been collated in this document, which is intended to supplement the initial synthesis report.

Initial recommended approaches from the synthesis document

1. Require and support a site-based approach that assesses the most likely dominant transport characteristics/pathways for the basis of BMP selection, in alignment with existing stewardship plans (e.g., environmental farm plans), programs and policies that support a site-based approach.

2. Structure further work and research assessing the efficacy of BMPs in the context of transport mechanism groupings. Investigate the potential to develop tailored regional or sub-regional assessments and characterizations that group main transport pathways, types of agricultural activity (e.g., crop types vs. livestock), and conditions for an area to better prioritize comparisons and selection of BMPs.

3. Adopt a risk-based framing for BMP assessments, discussions and outreach that recognizes the different risk management considerations to better recognize and align risk-sharing frameworks among producers and regulators.

4. Advance the knowledge base for existing measurements, like soil-test P, to gain a better understanding of long-term availability of soil P to avoid the over-application of fertilizers and recognize risks to the surrounding environment, as well as better understand the relationship of such measures to predicting P loss from the landscape.

5. Increase support for education and training regarding best application of source control options (e.g., 4Rs), structures with incentives and regulations that recognize and reflect the realities of decision needs for producers.

6. Advance initiatives that better highlight success stories and learnings from BMP applications not specific to assessment or promotion of individual technologies or practices, but that advance knowledge of what has been learned about the ability to manage transport.

Stakeholder outreach

Groups and individuals from the agricultural sector were asked to provide feedback on:

- Which of the recommended approaches would be seen as helpful or unhelpful by the farming community for reducing P losses, and why.
- How these recommended approaches, if implemented, could lead to changes in program design (related to upstream recommendations) and changes in farmer BMP choices in anticipation of more extreme weather events in their area (related to downstream recommendations).
- Suggestions on what is needed to accelerate implementation.

The participants were asked to consider the following questions:

- Of the six recommendations, which ones do you (or the group you represent) see as being most helpful to the farming community? Why?
- Of the six recommendations, which ones do you (or the group you represent) see as being least helpful to the farming community? Why?
- From your perspective, what changes do you think could be made to improve the clarity/wording or downstream implications of any of these recommendations?
- Which of these recommendations do you think have good potential to be implemented in the future? (You can define what "good potential" means, as well as what the timescale would be.) Why?
- Which of these recommendations do you think will encounter difficulties getting to implementation? What about during implementation? Why?

CWN discussed these questions with each of the participants in person, over the phone, or through email correspondence, depending on participants' location and availability.

Summary of feedback

Helpfulness of recommended approaches

All six recommended approaches were considered helpful by at least one group or individual engaged in this follow-up process, particularly when considered as an integrated approach to reducing P loss. That said, responses varied depending on perspective.

Overall, a site-specific approach, together with assessing the efficacy of BMPs in the context of transport considerations, alongside additional extension work and the use of case studies highlighting success stories (approaches #1, #2, #5 and #6), were thought to have good potential to help the farming community, if implemented appropriately. A site-specific approach was considered most helpful on the ground, with assessment of efficacy, risk-based framing and extension activities (#2, #3, and #5) helping make that happen, and case studies (#6) serving to support all of the above. A further suggestion was to ensure that an overarching outcome-based framework, with specific goals and commitments, ties these recommended approaches together (e.g. the Lake Erie Action Plan).

Some felt that advancing the knowledge base for existing measurements (approach #4) was least helpful as written, while others closer to the ground thought that it was useful from an implementation perspective.

Almost all farming community respondents indicated that approach #5 on effective outreach/extension/education was critical, and despite lack of clear consensus on who is best suited to deliver this outreach, it was clear that this is a priority for the majority of respondents. One group commented that it is difficult for farmers to see site-specific transport or BMP efficacy research as useful to their decisions until the knowledge is incorporated into education, training or extension efforts.

Implementation of recommended approaches

Work is already underway on many of the recommended approaches designed to move toward a site-based approach that considers dominant transport pathways. However, groups expressed the need for better coordination of efforts, as well as case studies, incentives and extension supporting this work.

Case studies

One respondent felt a site-specific approach and assessing BMP efficacy in the context of transport considerations (recommended approaches #1 and #2) were the most beneficial to farmers, but also the most difficult to implement. It is difficult for experts to recommend a particular practice as beneficial in all situations, but helpful to develop a series of case studies and gather input from farmers on their viability and efficacy (approach #6).

Incentives and co-benefits

Incentives are designed to help lessen the barriers for those interested in adjusting agricultural practices. While current funding programs are about sharing real and perceived risks of BMP implementation, including both financial and environmental risks, care must be taken in how these risks are framed. Several groups noted it is helpful to frame BMP adoption in terms of the co-benefits for farmers of improved water quality, resilience to flooding and drought, reduced soil erosion, and enabling financial cost-savings (e.g. nitrogen as an economic opportunity). If we are asking farmers to take on certain risks in order to achieve multiple benefits, extension programs are needed to help get them there.

Collaborative, peer engagement approach to extension

While it was acknowledged that education and outreach are already taking place in the farming community, several respondents indicated that more support is needed from the province. Respondents further noted that education and outreach should not necessarily be delivered by government, and that, at a minimum, government needs to be less "top-down" in its approach. Farmer peer-to-peer sharing is critical, but there should not be an expectation that farmers will simply volunteer their time in this regard.

Overall comments

A site-specific approach calls for – and can be the pathway to – major behavioural change, and is therefore linked to both incentives and extension. To implement changes over the long-term, more resourcing is needed for extension that is led by farmers and groups who are already doing this, as well as support for an adaptive approach that enables farmers to build on what works and doesn't work in their own conditions and ensure continuous improvement.

Clarity of language

Recommendation #1 on supporting a site-based approach

We understand that farmers have been hearing "site-specific" for some time. It is important to highlight where practices have and have not worked through case studies. Academics and other experts continue to publish success stories and lessons learned in journals, but these recommendations do not necessarily reach farmers. Implementing similar BMPs at different sites requires attention and some caution, given the multiple variables impacting effectiveness and the timing of results. This is where assessment tools and case studies can help farmers understand where P is coming from and what has worked to curb it. However, specifics and actual results will depend on context.

It was also noted that the 4R Nutrient Stewardship Framework for fertilizer application, currently under development by 4R Ontario, aligns with the assertion that nutrient management is site-specific. Maximizing nutrient uptake depends on both source application and control practices (such as timing and placement) in addition to transport. Implementation of 4R nutrient stewardship through 4R Certification serves as a means to measure improved on-farm management of nutrients and monitor agricultural sustainability. 4R Nutrient Stewardship Plans

are living documents meant to evolve over time through adaptive management and continuous improvement. What we heard is that 4R nutrient stewardship should be referenced as a complementary approach to reduce nutrient loads in watershed management and agricultural stewardship planning initiatives.

Proposed change to recommendation #1:

Require and support a site-based approach that assesses the most likely dominant transport characteristics/pathways for the basis of BMP selection, in alignment with existing stewardship plans, programs and policies that support a site-based approach (e.g., environmental farm plans, watershed management plans and 4R nutrient stewardship).

Recommendation #2 on assessing the efficacy of BMPs

No proposed changes.

Recommendation #3 on adopting risk-based framing for BMP assessments

There was positive feedback on reframing the issue for the farmer as a risk-based approach, by acknowledging the factors and trade-offs involved in producing a crop that is both economically viable and environmentally sustainable.

However, the term "risk" was interpreted differently by respondents. It was not clear to them whether risk-based framing implied financial risks to the farmer or the government for crop yield, other factors, risks to the environment, or all of the above. There was additional discussion on whether the approach relates to shared risks assumed by the government and farmers, or the overall risks associated with soil erosion, degraded water quality, flooding and drought conditions, etc.

While the synthesis document provides more context leading up to the recommendation to take a risk-based approach, based on prior work with the technical advisory group and workshop discussions, the risk should be broadly defined as all of the above.

In addition to risk, there are also economic opportunities for cost savings, particularly related to nitrogen. Farmers are responsive to aspects positively impacting their bottom line. Service providers play an important role in implementing and promoting BMPs on the ground, and should be noted in the recommendation.

Proposed change to recommendation #3:

Adopt a risk-based framing for BMP assessments, discussions and outreach that recognizes the different risk management considerations, including financial and environmental risks, to better recognize and align risk-sharing frameworks among producers, service providers, and regulators.

In addition to ensuring that science informs a risk-based approach, respondents indicated that it is important to consider farmers' perspectives on the benefits and risks associated with adopting

different BMPs. It was suggested that Table 3 (pages 19 – 20) in the original synthesis document be updated and expanded to reflect the risks to farmers (both real and perceived) as well as the costs, benefits and overall preferences of farmers who would be implementing the BMPs.

If we are seeking to adopt or promote use of a risk-based framing for BMP assessments, a more detailed understanding of costs, risks, benefits and barriers from the farmer's perspective may help shape the approach to outreach and extension (see proposed change to recommendation #5, below). Appendix A, authored by Melisa Luymes (Ontario Soil Network and Headlands Ag-Enviro), provides a more in-depth analysis of the importance of incorporating farmers' perspectives on risks associated with BMP implementation and the implications for improved extension.

Recommendation #4 on knowledge base for measurements like soil-test P

Some respondents expressed concern that data collected on soil-test P will lead to prescriptive regulations limiting nutrient application, which could result in hesitation to share data. Groups expressed concern that the risk should not be placed on farmers alone. It was suggested that crop advisors and retailers need resources to become 4R-certified and assume responsibility for the right amount applied.

Soil-test P provides information on the probability of a crop response. We have fairly good data on the relationship between soil-test P and crop response, but lack information on the relationship between soil-test P and environmental risk. Uncertainty is often used as a reason not to act.

Farmers need to know where P is being lost on the landscape, and whether and when they are doing enough to reduce nutrient loading while balancing crop yields. Several groups asked about the status of ongoing updates and improvements to Ontario's P index (proposed name change to PLATO, Phosphorus Loss Assessment Tools for Ontario). This index was originally designed to help characterize the risk of P loss and assist in selecting management strategies and setback requirements to reduce the risk. Improvements are expected to focus on 4R nutrient stewardship principles. However, there is confusion as to whether the new tools will be evidence-based and readily accessible to farmers, as well as proving helpful in making decisions about appropriate BMPs that ensure yields and reduce environmental impacts.

To promote the use of P management tools by the farming community (who must balance a number of time and resource demands), tools need to be easy to use, with an interactive, visual map-based application. They must be pragmatic in helping the farm community predict P loss from the land while not being totally prescriptive. It is important to continue working closely with the farm community to improve new tools and provide confidence that what they are doing is working to retain P on the land where it is most beneficial. Based on discussions about the usefulness and implementation of this recommendation as originally written, it has been changed below to focus on PLATO.

Proposed change in focus of recommendation #4:

Work with the farming community to further develop a P index (e.g., PLATO) that takes a pragmatic, practical and science-informed approach to prioritizing actions to mitigate P loss that will have the most value.

Recommendation #5 on education and training

As mentioned, several groups pointed to the need for additional support for extension, although there was not a clear consensus in the preliminary evaluations on how the messaging should be developed and who should be involved in the delivery. Some respondents suggested that the government take the lead in developing messages and providing tools and resources for those working on extension. Others suggested farmer-led exchange of ideas, success stories, and local lessons learned through community networks. A peer-to-peer approach is essential to agricultural stewardship, but resources are needed to support farmers to avoid burnout and facilitate greater uptake. In addition, "outreach and extension" are more palatable than the top-down perception implied by "education and training," so the wording should reflect this. It was not surprising to hear that outreach and extension are priorities for the farming community. Informal farmer-to-farmer exchanges, such as those conducted by the Ontario Soil Network and Yahara Pride Farms in Wisconsin, are highly effective.

Proposed change to recommendation #5:

Increase support for outreach and extension regarding the best application of source control options (e.g., 4R nutrient stewardship), and structure incentives as well as regulations to recognize and reflect the realities of decision needs for producers.

Recommendation #6 on highlighting success stories and lessons learned

Case studies are a means to communicate the effectiveness of BMPs in a given context. Members of the farming community indicated that the extent to which this recommendation is helpful depends upon the nature of the BMP. For example, if there is a new technology that has been proven and made available — and will work in a particular context — an on-farm demonstration would be useful. However, given the advent of multiple new technologies and increasing options for stewardship, farmers may choose to implement different practices from their peers. There was no proposed change to the wording for this recommended approach.

Revised recommended approaches

1. Require and support a site-based approach that assesses the most likely dominant transport characteristics/pathways for the basis of BMP selection, in alignment with existing stewardship plans, programs and policies that support a site-based approach (e.g., environmental farm plans, watershed management plans and 4R nutrient stewardship).

2. Structure further work and research assessing the efficacy of BMPs in the context of transport mechanism groupings. Investigate the potential to develop tailored regional or sub-regional assessments and characterizations that group main transport pathways, types of agricultural activity (e.g., crop types vs. livestock) and conditions for an area to better prioritize comparisons and the selection of BMPs.

3. Adopt a risk-based framing for BMP assessments, discussions and outreach that recognizes the different risk management considerations, including financial and environmental risks, to better recognize and align risk-sharing frameworks among producers, service providers, and regulators.

4. Work with the farming community to further develop a P index (e.g., PLATO) that takes a pragmatic, practical and science-informed approach to prioritizing where actions to mitigate P loss will have the most value.

5. Increase support for outreach and extension regarding the best application of source control options (e.g., 4R nutrient stewardship) and structure incentives as well as regulations to recognize and reflect the realities of decision needs for producers.

6. Advance initiatives that better highlight success stories and learnings from BMP applications, not specific to assessment or promotion of individual technologies or practices, but that advance knowledge of what has been learned through successes and failures about the ability to manage transport.

Appendix A: Farmer perceptions of risks, costs and benefits of BMP implementation

Melisa Luymes, Principal Consultant
8458 12th line RR1 Moorefield, ON N0G 2K0
mel@headlands.ca
519-820-2358

Feedback on April 2018 CWN synthesis document prepared for OMAFRA

Engaging Ontario farmers in BMP selection
Canadian Water Network c/o Dr. Katrina Hitchman
May 28, 2018

1) Consider farmers' perspectives in the BMP decision making process

When making decisions about which agricultural best management practices to promote in certain areas across the province, one of the most critical pieces to understand is a farmer's current perception of the practices. If the practice is relatively low cost and has a high efficacy, it may appear as the logical choice; however, if there is a high risk to the farmer or if the practice has low 'cultural capital' in the farming community, then there will be pushback from the farming community. Of course, this doesn't mean that farmers won't adopt the practice eventually, it only means that more research or outreach must be done before expecting wide-scale adoption. *If given options, which BMPs do farmers prefer?*

Wisconsin example: In Wisconsin, the state is supporting 23 farmer-led watershed councils with $750,000 a year. These farmers are responsible for choosing which BMPs to promote to their neighbours and how. In speaking with Rachel Rushmann, the program coordinator, there are trends across these groups:

- *Cover crops* are the primary BMP, with groups promoting different species in different watersheds, according to their conditions and concerns.
- *Soil testing* for nitrogen use efficiency and nutrient management.
- *Low disturbance manure injection* systems are being promoted in the areas with intensive livestock operations. *Composting manure* is also an up-and-coming trend in these watersheds.
- *No-till* is encouraged across the board, with planting equipment that have higher down pressure and can handle higher surface residue.
- *Buffer strips* and *grassed waterways* are also popular and, unlike in Ontario, there is no requirement that farmers have these structures designed by an engineer and installed by a certified erosion control contractor (which drastically increases the price of the project).

According to coordinator Dennis Frame, one particular watershed group (Yahara Pride Farms) is restructuring their traditional funding approach towards a pay-for-performance program in which each farmer is able to choose which BMP he or she wants to use in a particular area and is compensated based on the results of phosphorus reduction (modeled not measured).

Ontario example: Closer to home, evaluating the relative popularity of BMP categories based on all applications (both successful and unsuccessful) submitted to the Ontario Soil and Crop Improvement Association (OSCIA) will help OMAFRA better understand what farmers wish to implement. Under the Great Lakes Agricultural Stewardship Initiative (GLASI), for the Lake Erie/ Southern Lake Huron watershed, 850 Farmland Health Check-Ups were completed by farmers (with crop advisors) over three years and this made them eligible to apply for cost-share funding for BMPs. According to an email from Karen Jacobs of OSCIA, the most popular categories that were funded were:

- *Equipment customization* that reduced tillage, precision placed fertilizer, or reduced tire pressure to reduce soil compaction.
- *Cover crops* after a commercial crop (note that farmers who already use cover crops were ineligible for this category).
- *Adding organic amendments* such as compost or biosolids.

However, these trends reflect the projects that were funded by OSCIA, not the total applications from farmers, and the initial call for applications restricted the eligible BMPs, which means that Ontario's top BMPs may be more a reflection of OMAFRA's goals, rather than farmers. Careful evaluation of the nature of proposed projects coming from farmers, especially those that were ineligible, may give insight to future program design.

Putting decision making in farmers' hands: In 2017, it was my understanding that the Greenland Group was developing water quality modelling software into a smart phone app that would allow farmers to drag and drop various BMPs on a map of their field and estimate the reduction of phosphorus (this may be similar to the upcoming PLATO tool). The app was then to go a step further and create a cost:benefit scenario and, if the farmer was satisfied, he or she could upload this BMP to a provincial list for funders, accessible to Conservation Authorities, government and environmental groups. If they also felt there was a good cost:benefit ratio, funders could work with the farmer to implement the project. The other critical piece of this app was the reduction of paperwork, as one initial form would suffice for any funder. Trevor Boston presented this app at the AquaHacking competition in 2017, but unfortunately did not progress to the semi-finals.

Risk perception: Risk is the possibility of danger or loss. While we can study it statistically and objectively from afar, a sociological approach helps us to understand risk as it pertains to behaviour change. Risk is perception and perception is reality. To understand why a farmer might resist trying a BMP such as planting cover crops, we need to step into his or her shoes. Perhaps, and this is often the case, a relative or neighbour planted cover crops decades ago and had such a subsequent crop failure that he or she feared they would lose the farm. Furthermore, even if such a farmer doesn't believe there is a risk to planting cover crops, there is a *social* risk to the practice. In going against *social norms* of farming practice in an area, farmers may be risking relationships in their family and community, including their agricultural community of bankers, agronomists and salespeople. Farming practices are deeply personal and have been entrenched in the farming community for decades.

In this way, one negative experience will counter all the positive research and farmer stories that are promoted in the media. Of course, it is not impossible to shift the behaviour of such a farmer; but it will entail changing the nature of risk. Framing soil erosion as the greater risk and adjusting crop insurance to support best management practices is an example of such a shift. Providing greater technical support for farmers adopting these new practices will mean less 'disasters' and less negative press on the practice. And of course, promoting BMPs within the larger (more influential) agricultural community is key.

The perception of risk will vary from practice to practice. In Everett Rogers' now classic *Diffusion of Innovations*, the author argues that a practice will be more or less acceptable based on five key features:

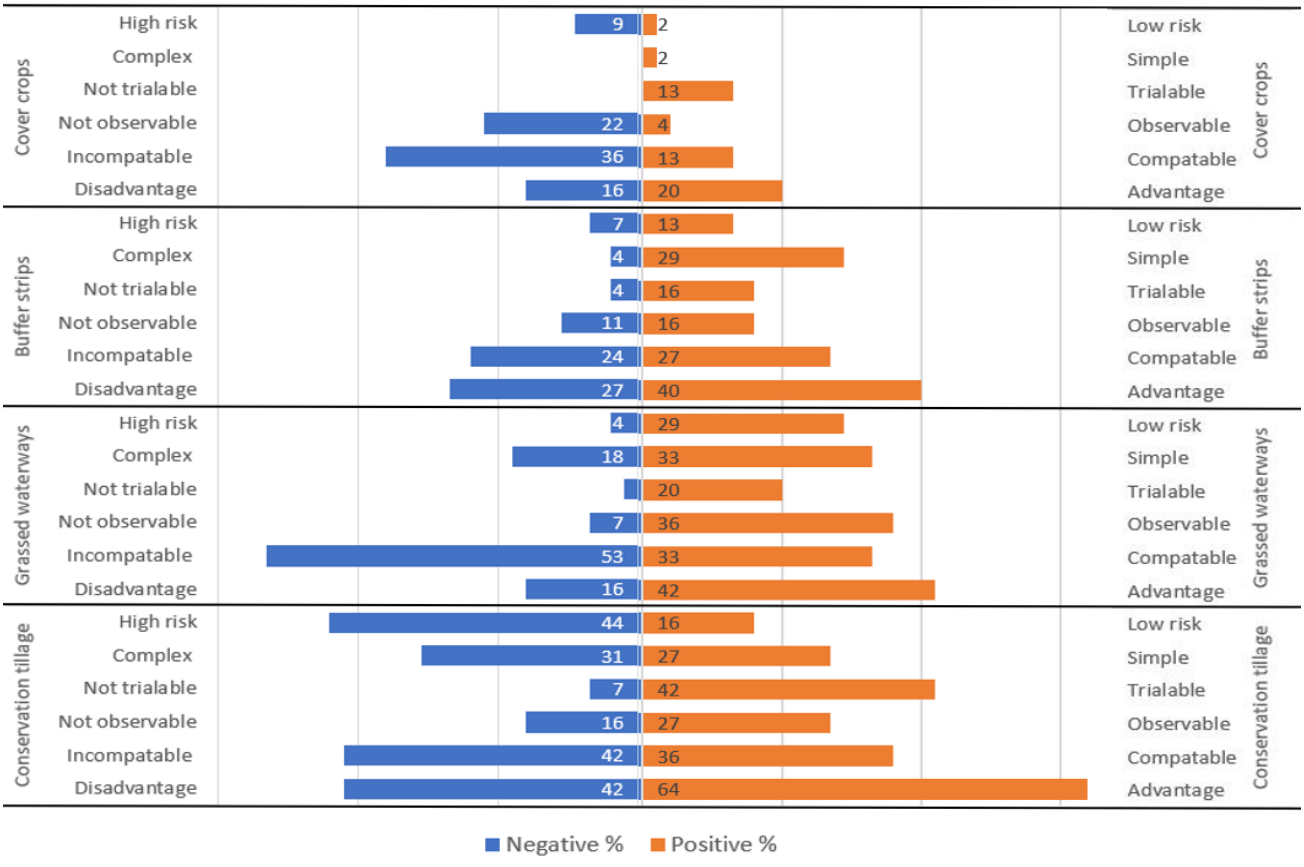
1. Relative advantage – is this practice better than the existing one?
2. Compatibility – is it consistent with the existing experience and tools of potential adopters?

3. Complexity – is it easy to implement?
4. Trialability – is it easily experimented with (trialed on just a part of the field)?
5. Observability – is the result visible?

Rogers also argues that for a farmer (or anyone) to adopt a new practice, he or she will first need to see the need to change. People need to 1) identify the threat as real and 2) believe it will negatively affect them and then 3) believe that the proposed solution is practical and 4) that it will effectively solve the problem. As I will briefly explore below, the farmer participants in a recent survey of Ontario farmers believed that the costs and risks of implementing BMPs were often less than the benefits to themselves and society, but a potential follow-up survey could examine a farmer's perception of the need for certain BMPs and the perceived efficacy of them.

Reimer *et al.* (2012) dig into Rogers' framework through qualitative interviews with 45 farmers in Indiana (in two sub-watershed areas). They asked farmers about their perceptions of four BMPs: cover crops, conservation tillage, grassed waterways and riparian buffer strips. They found that farmers commented on various acceptability characteristics, in both negative and positive ways. They reported on the percentage of both negative and positive comments as they pertained to the above five acceptability features, as well as risk. For positive characteristics, practices could be perceived to be: low risk, simple, trialable, observable, compatible, or have an advantage. Whereas, for negative characteristics, the inverse was the case: high risk, complex, not trialable, not compatible and having a disadvantage. Their statistics are summarized in Table 1.

Table 1: Indiana farmers' perception of four BMPs, by attribute (% of comments), Reimer *et al* 2012



A more qualitative summary of this research, along with a summary of my findings from 20 farmer interviews in 2017 in the Lake Erie basin and anecdotes from farmers in the Ontario Soil Network, is included here in Table 2.

Table 2: Positive attributes and challenges with BMPs

BMP	Description	Positive attributes	Challenges
Cover crops	Crop that grows between commercial crops to build soil fertility and protect soil.	Easy to try on just one part of the field. Improves fertility and soil quality.	Disadvantage due to increased cost and time requirements, as well as potential planting delay. Unpredictability of cover crop establishment. Low perceived need and lack of research.
Riparian buffer strip	Unworked, vegetated strip along ditch or watercourse.	Practical advantage to farmers for driving around field and economic benefit due payment programs.[1]	Disadvantage because removing land from production while still paying for it. Requires maintenance or weeds will become an issue in field. Not creating observable benefit and seen as unnecessary.
Longer crop rotation	Planting a rotation of at least three crops, in most cases this means *wheat* with corn and beans.	Wheat allows time for cover crops, manure application or drainage tile installation after harvest.[2]	Most farmers have had serious financial losses with wheat in the past.[2]
Wetlands	Receives surface or tile water to filter nutrients before discharge to stream.	Advantage if able to be used for irrigation.	Create problems with migratory birds that do crop damage and potential protected species which could increase land use restriction. Perceived as 'giving up' on land that a farmer has paid for.
No-till	Planting into an unworked seedbed to preserve soil structure and biology.	Economic savings more important than environmental benefit. Observing cleaner water.[1] Easy to try on just a section of the field. Good for the soil (but takes 5 years to see results).	Uncertain outcomes depending on the weather. Requires more careful management. Reduction of yield and delayed planting. Requires changing equipment and costly initial investment. Looks messy.
Grassed waterways	Permanently vegetated areas along low draws to minimize soil erosion.	Relative advantage for soil conservation and perceived as financial/operation benefit more than environmental. High observability to reduce soil erosion.	Some farms don't need it or don't feel it is needed. Takes time to maintain it (cutting) and can be a hassle to crop around. Difficult to do on rented land without landowner buy-in.

Windbreak	Row of trees that limit soil and crop desiccation and erosion	Reduces wind damage and increases yields in the field. Looks neat (if maintained).	Visibly reduced yield within a few metres. Fear that government will not allow the trees to be removed once planted.
4R Nutrient Stewardship	Nutrient use efficiency. Applying the right fertilizer at the right rate, in the right place at the right time.	Cost savings are a relative advantage. Efficiency is 'common sense.'	Expensive to upgrade equipment for smaller farmers. Timing of fertilizer application can be inconvenient.

1. Only observed in Reimer *et al* (2012)
2. Anecdotes from Ontario Soil Network (2017-2018)

To clarify the above chart, there are logical inconsistencies between the positive and negative perceptions of BMPs, because the 'facts' largely depends on a farmer's perspective, his or her farm and commodity type and his or her access to capital or labour. For example, economic savings motivate one farmer to do no-till, while yield reduction discourages another from the same practice. For farmers that do the math, they find that a yield reduction is manageable due to the economic savings of not paying for the tillage. This is further confounded by the lack of clarity of what constitutes a BMP. In the case of 4R Nutrient Stewardship, there is not yet a rubber-stamp approval verifying if a farmer is being efficient with nutrients. For now, it is a hazy concept. An erosion control berm (WASCoB), as another example, could be an expensive earth moving project or simply a few hay bales placed in a water run. Each will be perceived differently by a farmer.

Furthermore, both Reimer *et al* (2012) and Luymes (2017) found that a farmer's negative or positive perception of a practice is often correlated to whether they are doing the practice. This is illustrated by a common Dutch phrase: *What the farmer doesn't know, he doesn't like.* However, in the recent brief survey of Ontario farmers (conducted in May 2018), I found that this was the case for BMPs such as wetlands, strip-till and windbreaks, but not for grassed waterways or cover crops.

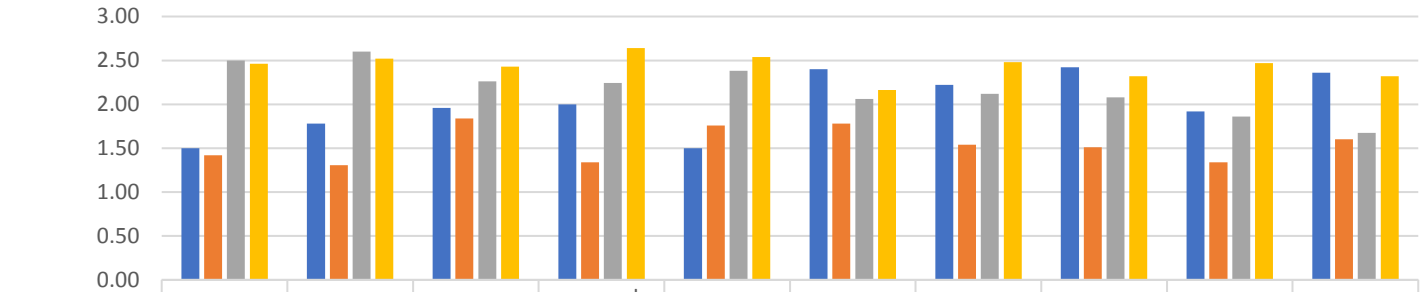
Farmer survey: I created a 5-minute online survey using Typeform (distributed through Twitter using #OntAg) for farmers to rate their opinion on ten different BMPs, to which 50 farmers responded. A photo and description of the BMP was featured, followed by the following four questions, answered high, medium or low:

- What do you feel is the level of cost to you to do it?
- What is the level risk to you in doing it?
- What is the level of benefit to you in doing it?
- What is the level of benefit to society in you doing it?

The survey concluded with questions that provide context:

- What type of farm do you operate?
- How many acres of land do you farm?
- Where in Ontario do you farm?
- Which of the 10 BMPs do you currently use?

Table 3: Ontario farmers' perception of various BMPs



	crop rotation	4Rs	cover crops	grassed waterway	no-till	strip-till	windbreaks	berms	buffers	wetlands
Cost	1.50	1.78	1.96	2.00	1.50	2.40	2.22	2.42	1.92	2.36
Risk	1.42	1.31	1.84	1.34	1.76	1.78	1.54	1.51	1.34	1.60
Pers. Benefit	2.50	2.60	2.26	2.24	2.38	2.06	2.12	2.08	1.86	1.67
Soc. Benefit	2.46	2.52	2.43	2.64	2.54	2.16	2.48	2.32	2.47	2.32

Responses of low, medium and high were valued as 1, 2 and 3. Table 3 summarizes the averages.

Though quite crude, these results do demonstrate that farmers perceive that the costs are higher than the (personal) benefits in the case of strip-till, windbreaks, berms, buffers and wetlands. On the other hand, longer crop rotation, no till, grassed waterways and 4R Nutrient Stewardship were the BMPs with the lowest perceived cost and higher perceived benefits.

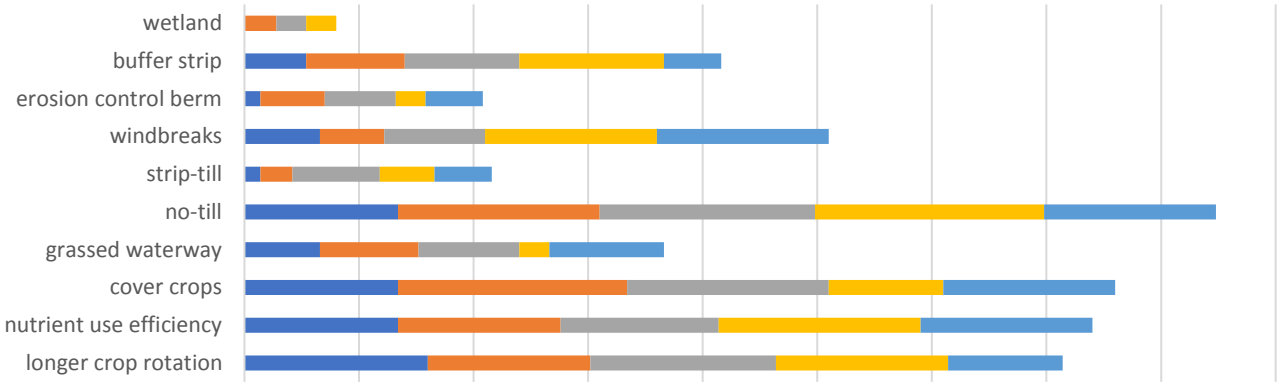
An important qualification is that many Twitter users are more progressive farmers and more likely to use BMPs and this may be leading to more favourable opinions them. The average number of the 10 BMPs used by survey respondents was 5. Furthermore, creating a scale of 1-to-5 or 1-to-10 even (instead of 1-to-3) would create more nuances in this data.

The percentage of farmers using individual BMPs is presented in Table 4 to demonstrate the relative adoption of these BMPS; while the same data presented on the other axis in Table 5 confirms evidence from the literature that farm size may be (slightly) correlated to BMP adoption, with the smallest and largest farms the least likely to adopt BMPs. This is why the 'disappearance of the middle' sized farms may be a growing concern to the environment in the future.

Though these results should not be considered rigorous nor, with only 50 responses, statistically significant, there are a few trends that emerge from this small survey that demonstrate how farm size may be correlated to BMP perception, though this would need to be qualified with further research. The case of strip-till is interesting because strip-tillage requires the purchase of a rather expensive piece of equipment and I thought that the larger operators would see the benefit of this practice more than the smallest producers, considering their ability to cash flow such equipment, but the opposite was true (Table 6). And it also appears that farmers who use strip tillage feel the cost is lower and benefit is higher than those who don't use it (Table 7). This is also the case for wetlands (Table 8) and windbreaks (Table 9). But this trend was not necessarily true for grassed waterways or cover crops. Here, the perceived risk of growing cover crops may actually be *higher* for those who have experience growing

them (Table 11). Of course, these results are not statistically significant, but it is well worth further research.

Table 4: Farmers using BMPs (% by farm size)



	longer crop rotation	nutrient use efficiency	cover crops	grassed waterway	no-till	strip-till	windbreaks	erosion control berm	buffer strip	wetland
under 400 acres (15)	80%	67%	67%	33%	67%	7%	33%	7%	27%	0%
400-800 (7)	71%	71%	100%	43%	88%	14%	28%	28%	43%	14%
800-1600 (16)	81%	69%	88%	44%	94%	38%	44%	31%	50%	13%
1600-5000 (8)	75%	88%	50%	13%	100%	24%	75%	13%	63%	13%
over 5000 acres (4)	50%	75%	75%	50%	75%	25%	75%	25%	25%	0%

Table 5: Farmers using BMPs (% by farm size)

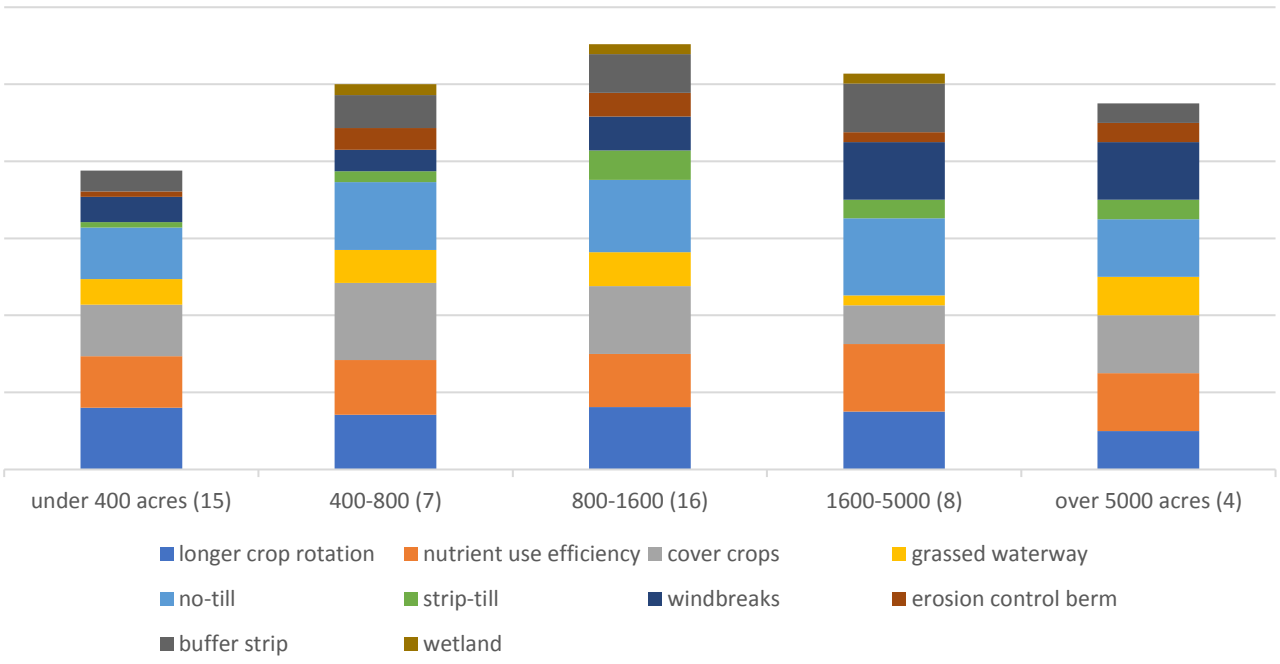


Table 6: Perception of strip-tillage, by farm size

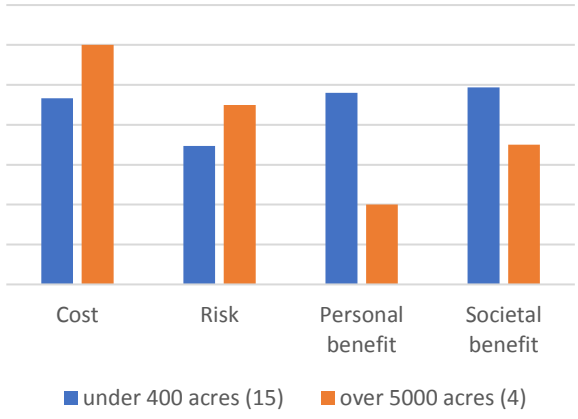


Table 7: Perception of strip tillage, by experience

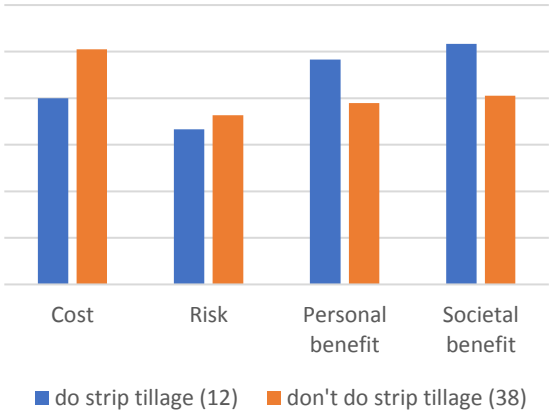


Table 8: Perception of wetlands, by experience

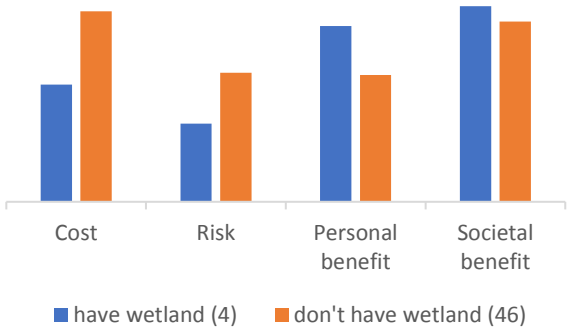


Table 9: Perception of windbreaks, by experience

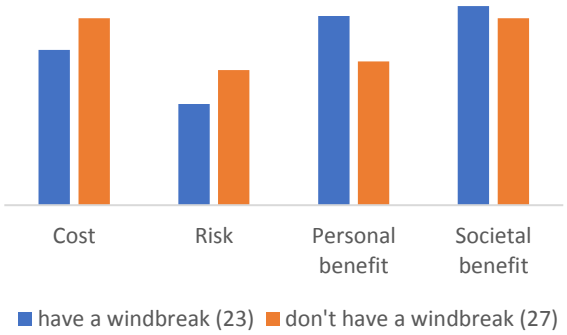


Table 10: Perception of grassed waterways, by experience

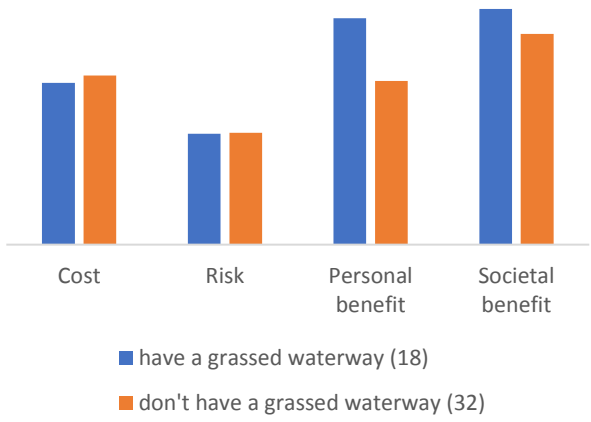
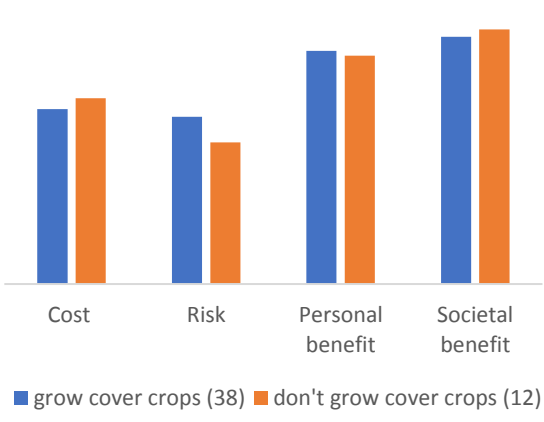


Table 11: Perception of cover crops, by experience



This preliminary study suggests that farmers have varying perceptions to BMPs and that these perceptions should be better understood by OMAFRA for the use of BMP selection. *The best BMP for an area or field would be the intersection of high efficacy, low cost and positive perception.*

2) Improve extension to farmers, with farmers

To connect with farmers, we meet them where they are. In most cases, farmers do not attend events led by the government and have a negative perception of OMAFRA since the field offices were closed in the 1990s. Most farmers do, however, read (parts of) the *Ontario Farmer*, have close ties with their crop advisors, bankers and equipment dealers, and attend church or community social events. These avenues, along with supporting peer-to-peer knowledge exchange, may be more effective at influencing farmers than large 'hit-and-run' conferences like the Southwest Agricultural Conference (SWAC). Of course, this may likely require a reallocation of government resources.

An individual's self-identity changes over time and farmer self-identity is no exception. Doug McKenzie-Mohr, in his experience of community based social marketing, understands that a small step (like signing a petition or a pledge) can often lead to a larger shift in behaviour because it shifts an individual's sense of identity. In this case, promoting the most positively perceived and widely adopted BMP may be this important first step for a 'middle-late adopting' farmer and lead to the next step to adopt another BMP. Furthermore, reframing farmers as environmentalists in the farm media by highlighting all the great work they already do may shift the collective cultural identity within agriculture, because when farmers are framed as polluters, they become defensive and their motivation to change is reduced.

Recommendations for improved extension:

- Increase technical support to farmers to reduce negative experiences with the BMP.
- Create agricultural outreach programs to involve the broader community, not just farmers.
- Focus outreach on reframing risk and increase self-identification as 'environmentalists.'
- *(Applies to all above recommendations)* Contract and support a third party to deliver, as OMAFRA may not have the same level of farmers' trust that it once did.

Works cited

Luymes, Melisa. 2017. "Now, its Personal: Social factors influencing the adoption of on-farm environmental practices in the Lake Erie watershed, Ontario Canada." *Report for Environment and Climate Change Canada.*

McKenzie-Mohr, Doug. 2011. *Fostering Sustainable Behavior: An introduction to Community-Based Social Marketing.* New Society Publishers, BC.

Reimer, Adam, Denise Klotthor Weinkauf and Linda Stalker Prokopy. 2012. "The influence of perceptions of practice characteristics: An examination of agricultural best management practice adoption in two Indiana watersheds." *Journal of Rural Studies* 28:118-128.

Rogers, E. 1962. *The Diffusion of Innovation*. New York, NY: The Free Press.