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Ontario Farmers for Agricultural Conservation

An NFU-O Report & Survey on Advancing Best Nutrient Management Practices

May 2024

Acknowledgments

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The National Farmers Union - Ontario (NFU-O) is made up of thousands of passionate, innovative farmers across Ontario working for a food and farm system that is better for farmers, eaters, and the land. The NFU-O connects these farmers and collectively raises their voices, turning big ideas into real change.

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Executive Summary

Farmers care about agricultural conservation. Over three quarters of the 246 Ontario farmers who took part in this NFU-O survey believe they have an important role to play in protecting water quality. A majority are also concerned about the rise of toxic Lake Erie algae blooms. Most are very aware that the re-eutrophication of Lake Erie is caused, primarily, by manure and synthetic fertilizers applied in the process of agricultural production.

Many of these same farmers have participated in voluntary programs or acted on their own initiative to adopt a myriad of best agricultural conservation and nutrient management practices, often at considerable personal expense. However, actual adoption of best practices rarely exceeds 50% of farmers. This is especially true of practices that offer little perceived financial benefit. Encouraging and financially supporting farmers who make voluntary ecological improvements is important, but so too is finding ways to increase adoption among those who don't or won't.

And here is why: **We've run out of time. With our current voluntary approach, we are not going to achieve the 2012 Canada-U.S. Great Lakes Water Quality Agreement goal of a 40% reduction in phosphorus loads entering Lake Erie by 2025.** Similarly, the federal goal of a 30% reduction in greenhouse gas emissions for on-farm fertilizer use by 2030 will pass by unrealized unless we make bold policy decisions that put ecological protection above the interests of fertilizer oligopolies and empower farmers to showcase their commitment to environmental stewardship.

Ecological, fiscal, risk, and efficacy concerns regarding the excessive and/or inefficient use of fertilizers were raised by many of the farmers who participated in this study. Many raised alarms at how current fertilizer practices can pollute watersheds and contribute to climate change. Others rightly complained about feeling gouged by fertilizer companies; on average, more than a fifth of conventional farmers' input costs are shelled out to buy fertilizer products from these mega-corporations.

A multi-pronged approach is required to adequately address and mitigate the agricultural sector's role in the re-eutrophication of Lake Erie and elsewhere and to realize the full potential of farmers' commitments to maintaining and improving water and soil health. A proactive and accountable farming community has the power to shift the dominant narratives away from denial or inaction by identifying and forwarding concrete farmer-led solutions to nutrient mismanagement and overuse.

The purpose of this study was to examine farmer attitudes and perceptions of nutrient management, including the risks and solutions to water contamination from animal manure and the agricultural application of nitrogen and phosphorus fertilizer.

The policy recommendations that come out of the results of this report and survey have been designed with the goals of:

1. showcasing farmer commitment to ecological protection;
2. making measurable and quantifiable improvements to soil and water quality across all agricultural operations;
3. challenging agricultural approaches that prioritize maximizing yields over profitability while disregarding negative environmental outcomes; and
4. ensuring that farmers can make a dignified and profitable living without damaging the land and water on which they depend.

Recommendations:

- **Reintroduce comprehensive Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) extension services for nutrient guidance:** We need government policy that supports the reintroduction of public extension services with trained agrologists capable of assisting farmers in calculating the most efficient and sustainable nutrient applications for their fields (including independent, i.e. non-corporate, advice on the right time, rate, source, and placement). **These extension services should also provide free annual soil testing for all farm operations.** This study found that less than 15% of conventional crop farmers regularly rely on OMAFRA's current nutrient management guidelines and the vast majority take commercial fertilizer suppliers' advice at face value, in spite of the evident conflict of interest.

- **Create a Canadian Farm Resilience Agency (CFRA)** to coordinate a rapid, science-guided, and least cost transition to financially secure, emission-minimizing farms and food systems. To reduce agricultural greenhouse gas (GHG) emissions and nutrient use across the country, we echo the call of the National Farmers Union and Farmers for Climate Solutions for the need for extensive, long-term support for farmers in: understanding and quantifying emissions; using fertilizer with maximum efficiency and effectiveness; optimizing and reducing use of other inputs; optimizing livestock systems; managing water and improving soils; and accessing agronomic advice independent of agribusiness corporations. A CFRA would help coordinate planning and delivery of agri-environmental and climate related programs across all provinces and territories (NFU, 2022; FCS, 2022).

- **Provide public education campaigns, including free and accessible training on "least cost crop production," or farming for maximum profit versus maximum yield:** Our survey data revealed that crop farmers spend, on average, one-fifth of their input costs on fertilizer and many shared concerns about the expense. This suggests that both the environment and farmers would benefit from education campaigns on practices/methods that reduce the total amounts of fertilizers required to grow their crops. These campaigns should also provide free and accessible training on the most up-to-date agricultural conservation practices. Many farmers were interested in exploring the possibilities of "least cost crop production" and farming for maximum profit rather than for maximum yield. Therefore, OMAFRA (and the proposed CFRA), alongside farm organizations, should offer workshops and/or specific guidelines to help farmers get off the yield maximization treadmill wherein they realize diminishing returns via the overapplication of synthetic fertilizers.

- **Increase quality and quantity of public and private grants, subsidies, and cost-share programs:** Financial supports, like those currently offered under the Ontario Agricultural Sustainability Initiative, are required to support farmers who make voluntary improvements by adopting best agricultural conservation practices. These grants and subsidies need to be easy to apply for, equitably administered, and long enough in duration to measure the efficacy of any intervention, including for projects that require repeated, continuous improvements. These funds should target specific practices that have typically been too costly for farmers to

voluntarily adopt, including those that may involve removing land from agricultural production (wetland and woodlot expansions, hedgerows, riparian buffer zones, etc.) to ones with higher upfront expenses (controlled tile drainage systems, specialized machinery, etc.)

- **Explore how participation in agricultural tax and federal program incentives could be made cross-compliant with the adoption and maintenance of on-farm agricultural conservation practices:** Such cross-compliant policy measures could include incremental revamping of Agriculture and Agri-Food Canada (AAFC) Business Risk Management programs, in particular AgriInvest, to incentivize farms that enact proven ecological improvements on their agricultural operations. Adding cross-compliance to current agricultural policy to achieve environmental goals could have the added benefit of helping to justify continued income support. **At the provincial/municipal level, we recommend exploring the possibility of making and sustaining ecological improvements a condition for farmers to receive either the full 25% agricultural property tax rate or introduce a further reduced conservation tax rate of less than 25% for those who adopt specific agricultural conservation practices.**

- **Revise the *Nutrient Management Act* (2002) to include synthetic fertilizer regulations and strengthen compliance measures:** Almost half of the farmers surveyed understood the need to augment voluntaristic approaches with specific regulations. We need to bring together farmers, scientists, and policy makers to design regulations that can serve as industry-wide standards in the use of synthetic fertilizers. In particular these regulations need to **make regular soil testing on all field crop farms a requirement** as it is impossible to adhere to sustainable 4R Nutrient Stewardship without it. These regulations might also include mandating the most effective agricultural conservation methods, such as riparian buffer zones, etc. B.C.'s Code of Practice for Agricultural Environmental Management (AEM Code) offers a useful template to begin these conversations. **These new and revised regulations, along with the ones already covered in the Act regulating greenhouses and livestock manure storage and application, need adequate compliance, monitoring, and enforcement both to be effective and to gain the public's trust.**

Introduction & Purpose of this Study

The purpose of this study was to examine farmer attitudes and perceptions of nutrient management, including the risks and solutions to water contamination from animal manure and the agricultural application of nitrogen and phosphorus fertilizer.

The need for this study was driven by a number of Ontario-based crop and livestock farmers who wanted to better collectively understand, address, and reduce agricultural nonpoint sources of dissolved reactive phosphorus (DRP). Originating primarily from synthetic crop fertilizers and livestock manure, DRP is the leading driver of the re-eutrophication of Lake Erie and the persistent spikes in Harmful Algal Blooms (HABs).

The eutrophication of the Lake Erie basin has fluctuated dramatically over the past 60 years. Phosphorus loads in the basin were high in the

1970s-1980s, but by the late 1980s, algae blooms decreased dramatically due to a) invasive mussels and b) a reduction in point sources, including improved sewage treatment and phosphorus restrictions in commercial detergents. A decline in fertilizer and manure application between 1975 and 1995, as well as agricultural efforts to control erosion (no-till, reduced-till practices) are also credited with getting the toxic algae blooms under control (Scavia et al., 2014; LimnoTech, 2019).

By the mid-1990s, HABS plagued Lake Erie again, killing fish and creating dead zones. The lake's water quality and ecological health, as monitored by the National Oceanic and Atmospheric Administration in the U.S. and Environment and Climate Change Canada (ECCC), has been in crisis condition numerous times since. Scholars are unanimous that agriculture is the primary source of the current re-eutrophication and HAB issues. They estimate that as much as 85% of the phosphorus causing the re-eutrophication of the Lake Erie basin can be linked to nonpoint sources, particularly from agriculture and food production, with climate change related extreme rain events contributing to the leaching of manure and synthetic agricultural fertilizers into the watershed (Kane et al., 2014; Wilson et al., 2019; Fraker et al., 2023). In particular, scientists have attributed increases in phosphorus to manure produced by livestock (including large concentrated animal feedlot operations) and synthetic fertilizer use by greenhouses and conventional crop operations along several Lake Erie tributaries, in particular the Maumee, Detroit, Sandusky, and Cuyahoga rivers in the U.S. and the Grand, Cedar/Essex, and Lower Thames watersheds in Ontario (Scavia et al., 2014; LimnoTech, 2019).

Manure and synthetic fertilizer leaching from Ontario-based farms into the Lake Erie basin currently pale by comparison to U.S. nonpoint sources. The U.S. is responsible for between 70% and 90% of the total phosphorus load in the Lake Erie basin (Scavia et al., 2014; ECCC, 2023). ECCC's tracking of Canada's Lake Erie phosphorus load—which includes point, nonpoint, as well as Canada's calculated contribution of loadings via Lake Huron and the atmosphere—reports that Canada's total phosphorus contribution ranged between 16% and 22% between 2010 and 2022, with a total of 9,379 tonnes discharged in 2022 (ECCC, 2023). ECCC also estimates that agricultural nonpoint sources accounted for 77% of Ontario's contribution to Lake Erie phosphorus loading in 2022, down from a high of 81% in 2019 (ECCC, 2023).

Although annual information is not available, the majority of Ontario's responsibility for Lake Erie re-eutrophication can be sourced to synthetic fertilizers. In 2011, 65% of Canada's nonpoint phosphorus load contributions came from synthetic fertilizers, and the remaining 35% from manure (LimnoTech, 2019).

That Ontario's agricultural and greenhouse operations are responsible for upwards to a quarter of Lake Erie's phosphorus loading is concerning. Some estimate that Lake Erie algal blooms are impacting the Canadian economy by $272 million annually and may cost Canadians as much as $5.3 billion over the next 30 years (GLSAB et al., 2023). Localized toxic blooms in the Chatham-Kent area, including those requiring swim advisories around Point Pelee National Park occurred in 2015 and 2018 and are attributed to Ontario nonpoint sources of phosphorus (Isaac & Loë, 2020). A recent study found that Leamington area tributaries near greenhouse operations were testing at phosphorus levels 100 to 200 times higher than provincial targets (ERCA, 2023).

With toxic algae blooms again on the rise, scientists have warned that algal bloom severity will only worsen with climate change. Their models suggest extreme spring precipitation will mean many farmers will need to reapply fertilizers lost due to surface runoff. **Agricultural experts warn that only widespread implementation of on-farm nutrient conservation and a variety of best management practices will adequately restrict phosphorus from manure and fertilizer from entering Ontario's Grand and Thames watersheds and bring Lake Erie's blooms to management levels** (Fraker et al., 2023; Scavia, et al., 2014).

While phosphorus is often the primary limiting nutrient in freshwater for phytoplankton growth, excess nitrogen loading also increases the risk of toxic cynaobacteria blooms (Gobler et al., 2016). Thus, management actions should target reductions in both phosphorus and nitrogen inputs to mitigate HABS (Gobler et al., 2016). Like phosphorus, upwards to 80% of the total nitrogen load (as nitrate, or NO3-N) in freshwater systems in Quebec and Ontario can be attributed directly to agricultural activities, either through runoff and leaching or from gaseous forms of nitrogen entering surface waters through wet and dry deposition (Rasouli et al., 2014).

Unlike the fairly stable amount of phosphorus use over the past couple of decades, synthetic nitrogen fertilizer use has almost doubled in Canada since 2006. Nitrogen fertilizers require a tremendous amount of natural gas to produce, with one tonne of fertilizer containing the equivalent energy of 1.7 tonnes of gasoline (Qualman & NFU, 2022).

As the NFU's Darrin Qualman reports, nitrogen fertilizer "is the primary reason that agricultural [greenhouse gas] emissions in this country are rising" (Qualman & NFU, 2022). Of the 13.8 million tonnes (Mt) of carbon dioxide greenhouse gas (GHG) emissions from Ontario agricultural operations in 2021, 3.0 Mt Co2, or 22%, could be sourced to nitrogen fertilizers (NFU, 2023). If we take into account the fact that most livestock are raised on crops sustained by these synthetic fertilizers, their manure (nitrogen, phosphorus and enteric methane emissions), are also a byproduct of conventional agriculture's reliance on fossil fuel-derived nutrients.

Ecological, fiscal, risk, and efficacy concerns regarding the excessive and/or inefficient use of fertilizers were shared by many of the farmers who participated in this study. Many raised alarms at how current fertilizer practices have not only polluted watersheds, but are a leading contributor to climate change. Others rightly complained about feeling gouged by fertilizer suppliers; on average, more than a fifth of conventional farmers input costs are shelled out to buy fertilizer products from these mega-corporations.

Tractor sprays liquid fertilizer onto a young wheat field. (*Canva*)

In 2012, under the amended Canada-U.S. Great Lakes Water Quality Agreement, the Governments of Canada and Ontario committed themselves to a goal of a 40% reduction in phosphorus (P) loads entering the Lake Erie basin by 2025 based on 2008 levels (Isaac and de Loë, 2020). Ten years later, a report prepared for the International Joint Commission concluded that "little progress toward 40 percent reductions of nonpoint P loads to Lake Erie has been realized" (GLSAB, 2023). According to Environmental Defence Canada, neither government has shared detailed plans on how they intend to achieve this goal, even though we are only a year out from the target reduction date (Woodhouse, 2023).

Fertilizer Canada—the industry association of producers, manufacturers, and retailers of crop fertilizers—, as well as major agricultural producers and agribusinesses, promote a particular storyline that depicts the current eutrophication crisis as too complicated, and so poorly understood that no real action can be taken to resolve it (Isaac and de Loë, 2020). By minimizing agriculture's role in eutrophication, any solutions "are couched in terms of incremental, voluntary and incentive-based 'business-as-usual' actions," conclude a team of University of Waterloo researchers (Isaac & de Loë, 2020). This voluntary approach, the authors note, is also the position taken by the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA), the provincial ministry responsible for regulating the farm and food sector. The voluntary, "it's complicated" narrative, Isaac and de Loë suggest, has been driven by the desire of fertilizer companies and corporate agricultural lobbyists to avoid regulation. So far, these corporate interests have successfully watered down any proposal that might actually achieve industry-wide standards to advance agricultural conservation.

A counternarrative, note these same University of Waterloo researchers, is made by nonprofit environmental groups who take the perspective that government inaction and a lack of agricultural nutrient regulation is to blame for Lake Erie eutrophication. Those who advance this narrative argue that the agricultural sector should be required to take measures to reduce their nutrient off-loading to the same extent as have municipalities (Isaac & de Loë, 2020).

This report seeks to offer another narrative that, instead of deflection or blame, empowers change through collective action. This storyline centres the voices of farmers who want to pursue individual and collective, voluntary and regulatory, novel and tested, government and scientifically-supported, agricultural conservation practices and policies that will:

- showcase farmer commitment to ecological protection and the mitigation of climate change;
- make measurable and quantifiable improvements on soil and water health across all agricultural operations;
- challenge agricultural approaches that prioritize maximizing yields over profitability while disregarding negative environmental outcomes; and
- ensure that farmers can make an honest and fair income without damaging the land and water on which they depend.

To realize these ideals, we must turn to the expertise of farmers themselves.

Methodology

This study surveyed Ontario farm operators to learn from them about the barriers and opportunities that exist to improve on-farm nutrient management practices.

The surveys were designed with Survey Monkey and developed in consultation with Lake Erie basin farmers and other stakeholders. All surveys were advertised in NFU-O e-newsletters and social media, and by rural stakeholders and other non-profit farm and food organizations.

A total of 246 participants completed the survey between 11 May 2023 and 31 October 2023. The survey initially targeted Ontario farmers in the Lake Erie basin and was later extended to farmers across the province. A logic-driven survey of 111 questions, the survey typically took between 45 minutes and 1 hour to complete.

Half of the surveys were completed online while the other half were completed over the phone with the assistance of the NFU-O nutrient management contract staff. Phone call surveys targeted both NFU-O and non-NFU-O farmers in the Lake Erie Basin. The Christian Farmers Federation of Ontario (CFFO) also released the survey to their members in the fall of 2023. The CFFO shared the non-identifiable data they gathered from 85 respondents, or 35% of the total participants. In total, just over half of the survey respondents were NFU-O members (53%).

Methodology and analysis were also informed by a literature review of relevant, peer-reviewed studies and secondary sources and conversations with agricultural conservation experts; these sources have been incorporated into this report.

Results

Overview of Survey Participants

All farmers surveyed (n = 246) were asked about their farm location, size, and ownership, the types of commodities produced, farming methods, and their proximity to surface water.

Farm Location, Size, and Ownership

Approximately 59% of the 246 survey respondents reported being in the Lake Erie basin; (some or all of the Southern Ontario counties of Brant, Chatham-Kent, Elgin, Essex, Haldimand-Norfolk, Hamilton, Lambton, Middlesex, Niagara, and Oxford are part of the Lake Erie watershed). Farmers in the counties of Chatham-Kent and Elgin were the most frequently represented.[1]

Farm sizes ranged from under 10 acres to over 2,880 acres. Small to mid-sized farms under 239 acres represented 46% of those surveyed.

Most participants (67%) indicated that they owned all the land they farmed and 30% shared that they have both owned and rented land.

Commodity Types and Farm Methods

Field crop farmers comprised the majority of those surveyed. (Figure 1). Three-quarters of respondents grew field crops, while another 54% raised livestock and 32% produced specialty products. Over half of respondents (53%) reported producing a mix of commodities.

About 60% of respondents declared they farm conventionally (i.e. they use both synthetic fertilizers and pesticides), while 28% reported farming organically, i.e., without use of chemical fertilizers and pesticides (Table 1).[2] Of the organic producers (n = 70), approximately half were certified organic, while the other half reported using organic methods but were uncertified.

Figure 1: Farms by Product Type

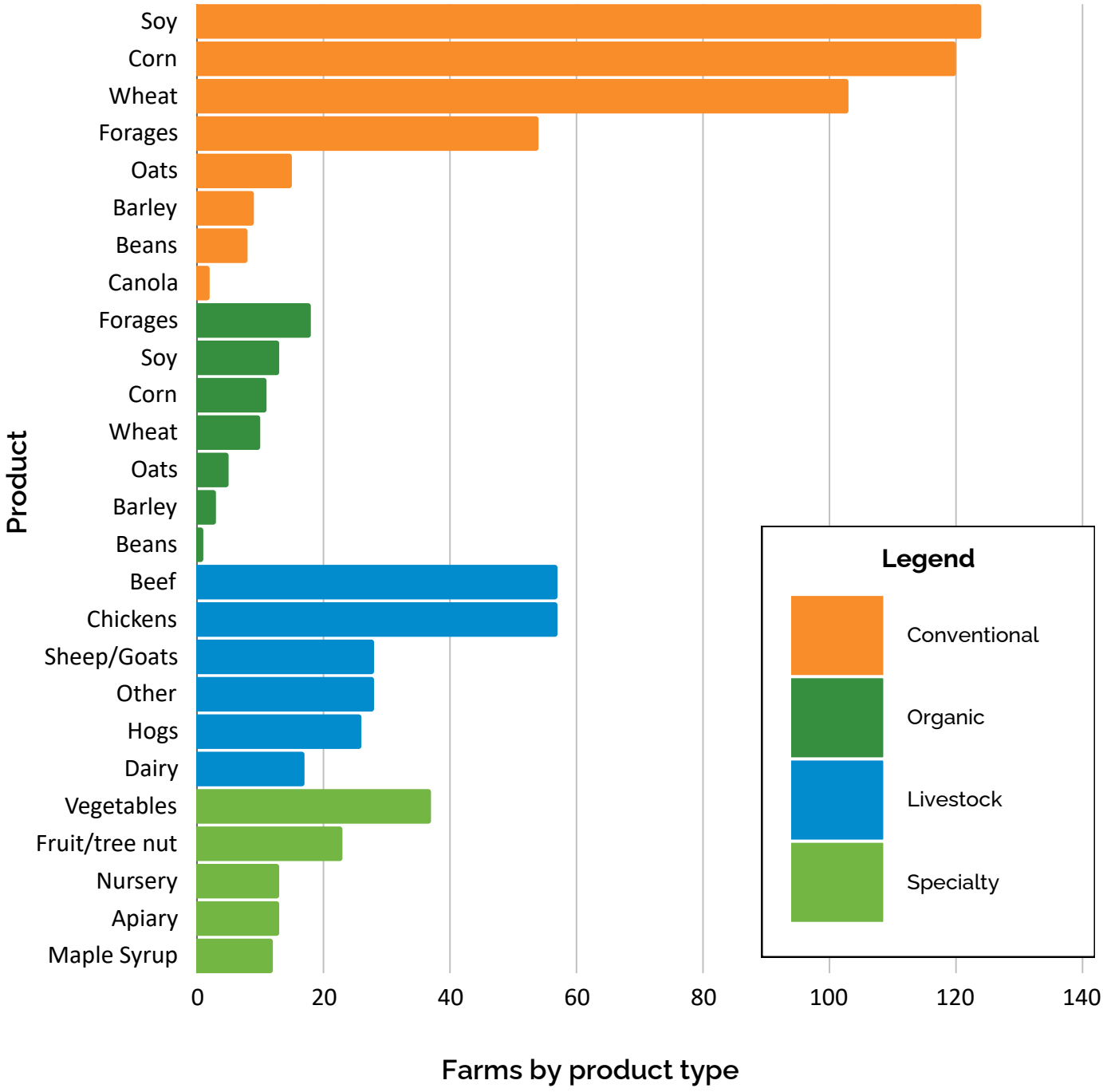


Figure 1. The number of nutrient management survey participants that reported producing each agricultural commodity type.

Table 1: The number of survey respondents by farming method

Farming methods	Number of respondents (n = 246)
Conventional	147
Certified Organic	34
Organic methods (uncertified)	36
Regenerative	30
Ecological	26

Approximately 12% and 11% of participants reported using regenerative or ecological farming methods, respectively.

Over 81% of exclusively field crop farms (n = 75) reported using conventional farming methods, while 5.3% were organic (Table 2). For livestock-only farms (n = 14), 14% identified as strictly conventional and 29% reported using organic methods. Almost 12% of exclusively specialty crop farms (n = 17) reported using conventional methods while 71% reported using organic methods. Of the mixed commodity farms, approximately 53% were conventional and 28% were organic (Table 2).

We did not gather enough representative data from greenhouse operators (n = 7), but nutrient management issues related to greenhouses raised in the scientific literature and/or shared by participants are included in this report where relevant.

In what follows, we focus primarily on the survey data associated with production systems that potentially release nutrients into the environment: conventional farming (which involves applying synthetic forms of nitrogen and phosphorus), organic farming (characterized by the use of organic forms of nitrogen and phosphorus and lack of synthetic fertilizers), and livestock farming.

Proximity to Surface Water

Most respondents (93%) indicated that there was at least one type of surface water on or adjacent to their property, with drainage/municipal ditches being the most frequently selected water feature, reported by 63% of respondents. Approximately a third farmed on land with a stream (33%) or a pond (35%) and a quarter indicated a wetland feature nearby.

It is primarily via these water features that nutrients are retained and removed (e.g., via wetlands) or drained/leached into larger watersheds (e.g., via ditches, streams, and groundwater). Many studies have reported elevated nutrient concentrations in Ontario agricultural surface and/or tile drainage waters (e.g., Dalton et al., 2015; Tan et al., 2002) that exceed the water quality limits for eutrophication and HABs (0.03 mg/L total P and 1.1 mg/L total N for the Mixedwood Plains of Ontario) (Chambers et al., 2012).

Protecting and preventing nutrient runoff into all surface water is key to reducing eutrophication and HABs (see the “soil and water control practices”

Table 2: The number of farms represented in the survey sample by farm type and farming method, as it pertains to synthetic nutrient use.

Farm Type	Farming Method		
	Conventional	Organic	Both
Field crops	61	4	1
Livestock	2	4	1
Mixed commodities	68	36	4
Specialty	2	12	1

section on p. 25). Practices designed to reduce nutrient loading to surface waters include: efficient fertilizer management (i.e., 4R stewardship), establishing erosion and runoff control features such as vegetated buffer strips, drain management systems to slow or retain tile drainage water, and the creation and maintenance of wetlands for nutrient retention and removal (Scavia et al., 2014; Fraker et al., 2023).

Farmer Attitudes and Environmental Concerns

Understanding farmer behaviors and/or attitudes is crucial to informing how policymakers might advance best agricultural conservation practices (Zheng et al., 2016; Wilson et al., 2018; Schwab et al., 2021). A recent Canadian Agri-Food Policy Institute (CAPI) survey found that 68% of a sample of 720 farmers across the country fell under the broad category of "sustainable improvers." Sustainable farmers were defined by the CAPI authors as those who considered themselves "good environmental stewards," but who still believed there was room for improvement (McCann & Lika, 2023).[3] A study investigating the factors that motivate farmers to adopt timing-related best practices for nutrient management found that perceived efficacy—the belief that a particular practice will actually be successful—was positively associated with a higher likelihood of adopting each of the BMPs investigated (Zhang et al., 2016). Thus, outreach and policies aimed at increasing farmers' perceived efficacy of practices could lead to higher adoption rates. Taken together, the results of those surveys suggest there is a general openness among farmers to making positive changes, but that the likelihood of doing so by adopting particular beneficial practices is influenced by individual attitudes and beliefs about those practices.

For the purposes of this study, we asked respondents several questions to ascertain their attitudes and level of concern regarding water quality, Lake Erie algal blooms, and agricultural conservation practices.

Farmer's role in protecting water quality

Over three quarters (78%) of all participants responded that they believe farmers have an important role to play in protecting water quality. Only 9% selected "it depends" and only 1.2% answered "no." The responses of conventional and organic producers were mostly in alignment, although slightly more conventional respondents selected "it depends" (Figure 2).

Figure 2: Do you believe farmers have an important role to play in protecting water quality?

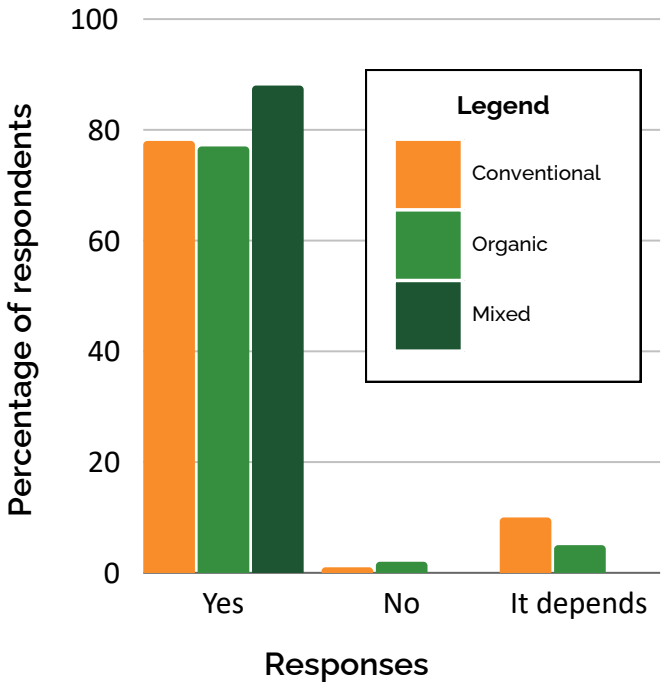


Figure 2. Do you believe farmers have an important role to play in protecting water quality? Conventional (n = 139), organic (n = 61), and mixed (n=8)

However, a significant number of farmers also expressed the sentiment that farmers are being unfairly blamed for water pollution and some responsibility should also lie with greenhouse operators, golf courses, municipal sewage plants and grey water dumps after heavy rainfalls, leaking cottage septic beds, etc.

While urban sources are a contributor to nutrient contaminants in Lake Erie, the existing scholarship has calculated that as much as 85% of the current eutrophication is caused by nonpoint agricultural sources, including livestock waste and synthetic fertilizers used in both greenhouse and field crop operations (ECCC, 2023; Kane et al., 2014; Fraker et al., 2023). In fact, since 2013, Scott's Miracle-Gro, the most common of lawn care products, has been phosphorus-free, significantly reducing the potential loss of phosphorus from residential and recreational areas like suburban lawns and golf courses (Wilson et al., 2019). Urban stormwater is, similarly, only a fraction of the total nonpoint sources of phosphorus, and is heavily regulated in Ontario.

Education informed and designed by and for farmers to raise awareness of the industry's overall contribution to watershed nutrient overloading is clearly still needed.

While some farmers downplayed the extent of agriculture's role in eutrophication, others called on the sector to take accountability.

> ***[The agriculture sector] should be [held] responsible. Manure and runoff from fertilizers is causing massive disruption of freshwater.***
>
> **– Farmer Survey Respondent**

Of course, agricultural operations vary in their nutrient losses based on existing soil quality, the commodities produced, and the agricultural methods deployed. Being painted with the same brush as farmers who appear to not be as ecologically conscious as they are was a source of frustration for many respondents.

> ***Many farmers try to do everything just right while the neighbour down the road just doesn't seem to care. This can be very frustrating.***
>
> **– Farmer Survey Respondent**

Agricultural Conservation & Nutrient Management

To address this common frustration, participants were asked if they were concerned about nutrient management practices on adjacent or neighbouring farms affecting the local environment (including the watershed) or their farming operation. Approximately 39% said they are concerned about the impacts of neighbouring farm fertilizer and manure use on the local environment and one in five expressed worries that these practices negatively affected their own operations. Just under half of respondents were not fazed by the nutrient applications of their neighbours. A higher percentage of organic field crop farmers were concerned by neighbour practices compared to conventional growers (Figure 3) and conventional growers more frequently reported that they had no concerns.

Neighbouring greenhouse operations were among the most likely to concern respondents. The growth of greenhouses producing specialty crops in the Leamington area almost doubled phosphorus loading in the Cedar/Essex and Lower Thames watershed between 2002 and 2012 (LimoTech, 2019). Since then, specialty crop and cannabis greenhouse operations have grown exponentially. As Essex farmer and journalist, Matt McIntosh, reported in *The Narwhal*, the proliferation of poorly-regulated greenhouse operations in the

Figure 3: Concerns about neighbouring farms' nutrient management practices

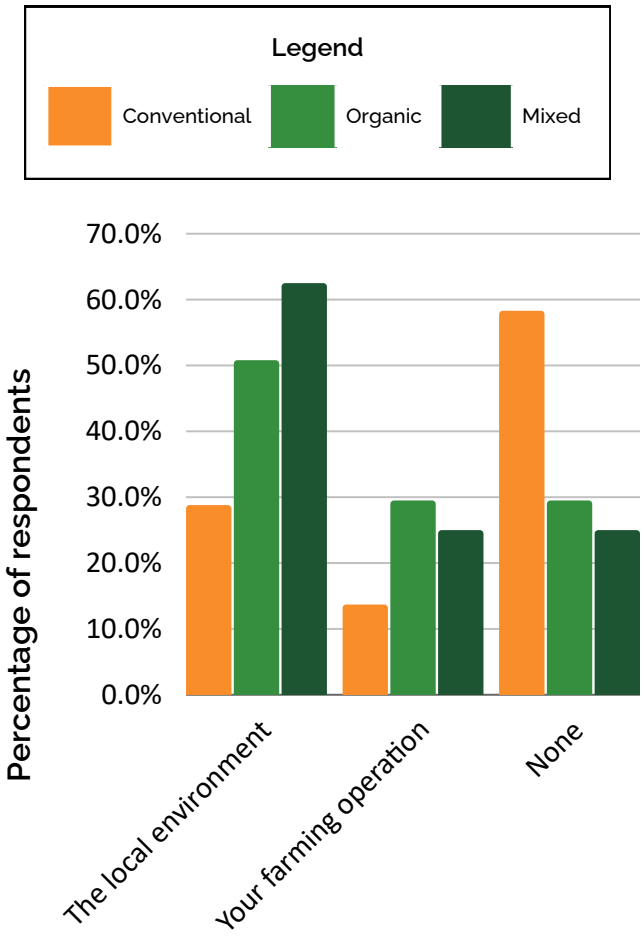


Figure 3. Percentages of conventional (n = 139), organic (n = 61), and mixed (i.e., reported using both conventional and organic methods; n = 8) that reported concerns about neighbouring farms' nutrient management practices.

region by more than 44 million square feet since 2016 has been seen by many experts and local political leaders as a leading source of excessive phosphorus concentrations (McIntosh, 2023).

And they are not wrong. A 2023 report prepared by the Essex Region Conservation Authority revealed that between 2017-2021 Leamington tributaries adjacent to greenhouse operations were tested at levels ranging between 2.9 to 6.0 mg/L total P, or over 100-200 times higher than provincial targets. Over 10 years of data collection indicated a trend of greenhouse influenced streams being more than 20 times higher in concentrations of phosphorus compared with non-greenhouse influenced streams (ECRA, 2023). Convictions against operators who violate existing regulations have been exceedingly rare (McIntosh, 2023).[4] It is not that greenhouses can't be managed to mitigate against nutrient off-loading into watersheds; of the 13 operations that participated in this survey, several indicated that they operate on closed loop systems that sustainably recycle waste water.

Farmer respondents to this survey, many of whom neighbour these large greenhouse operations, were vociferous in their complaints of what they see as systemic environmental mismanagement by greenhouse operators. Some shared that they have witnessed regular dumping of greenhouse waste water on open fields and ditches.

> ***They're [greenhouse operators] not following the rules, it's like the wild west.***
>
> **– Farmer Survey Respondent**

Lake Erie Algal Blooms

Exactly 60% of respondents indicated that the Lake Erie algae blooms worried them: 28% said they were very concerned about the blooms and 32% shared that they were somewhat concerned. Approximately 15% confessed they were unaware of the issue and 13% said they were not concerned. Compared to conventional producers, more organic farmers reported they were "very concerned" about the blooms, and fewer reported that they were "not concerned" (Figure 4).

However, more organic producers also reported being unaware of the issue. Unsurprisingly, the data also revealed that respondents from the Lake Erie basin were more likely to be concerned about the blooms than respondents outside of the basin (Figure 5). When asked if they were aware of the economic and health impacts of Lake Erie algal blooms, 47% of all survey respondents replied yes, 24% were unsure, and 17% replied no.

To better understand respondents' environmental concerns and the role they play in nutrient use and application, we need to explore the particularities of their operations.

Lake Erie algal blooms from August 2017. (*Aerial Associates Photography Inc. & Zachary Haslick*)

Figure 4: Level of concern about the Lake Erie harmful algal blooms

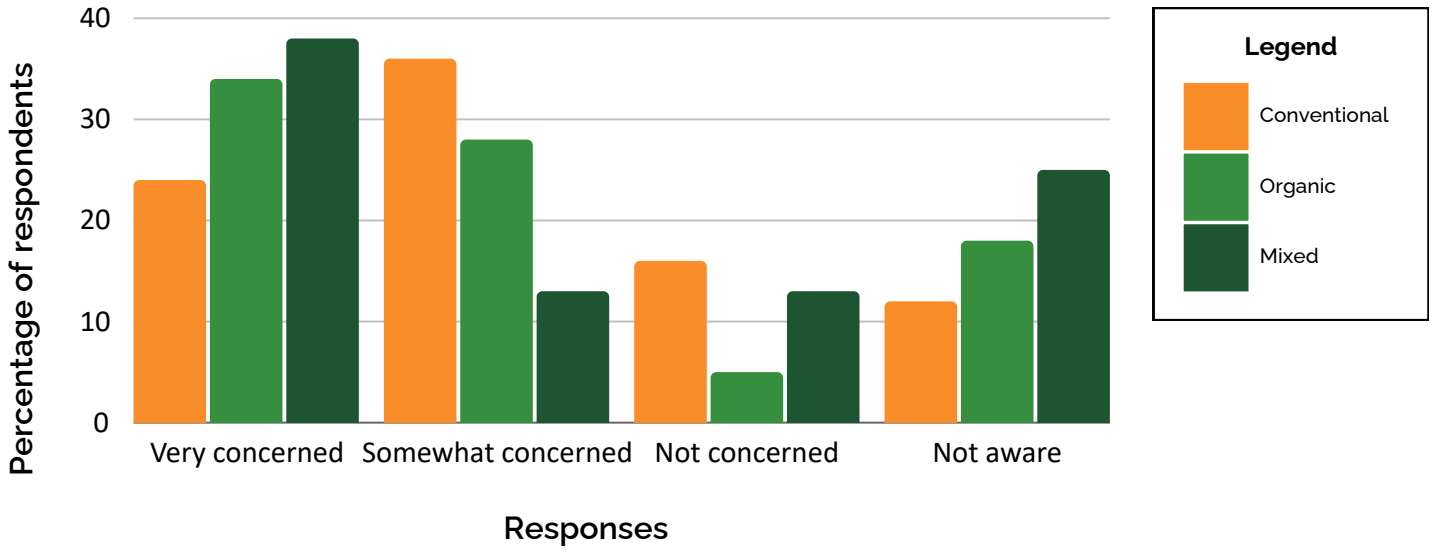


Figure 4. Percentages of conventional (n = 139), organic (n = 61), and mixed n = 8) nutrient management survey participants that selected each level of concern about the Lake Erie harmful algal blooms.

Figure 5: Level of concern about the Lake Erie harmful algal blooms (by location)

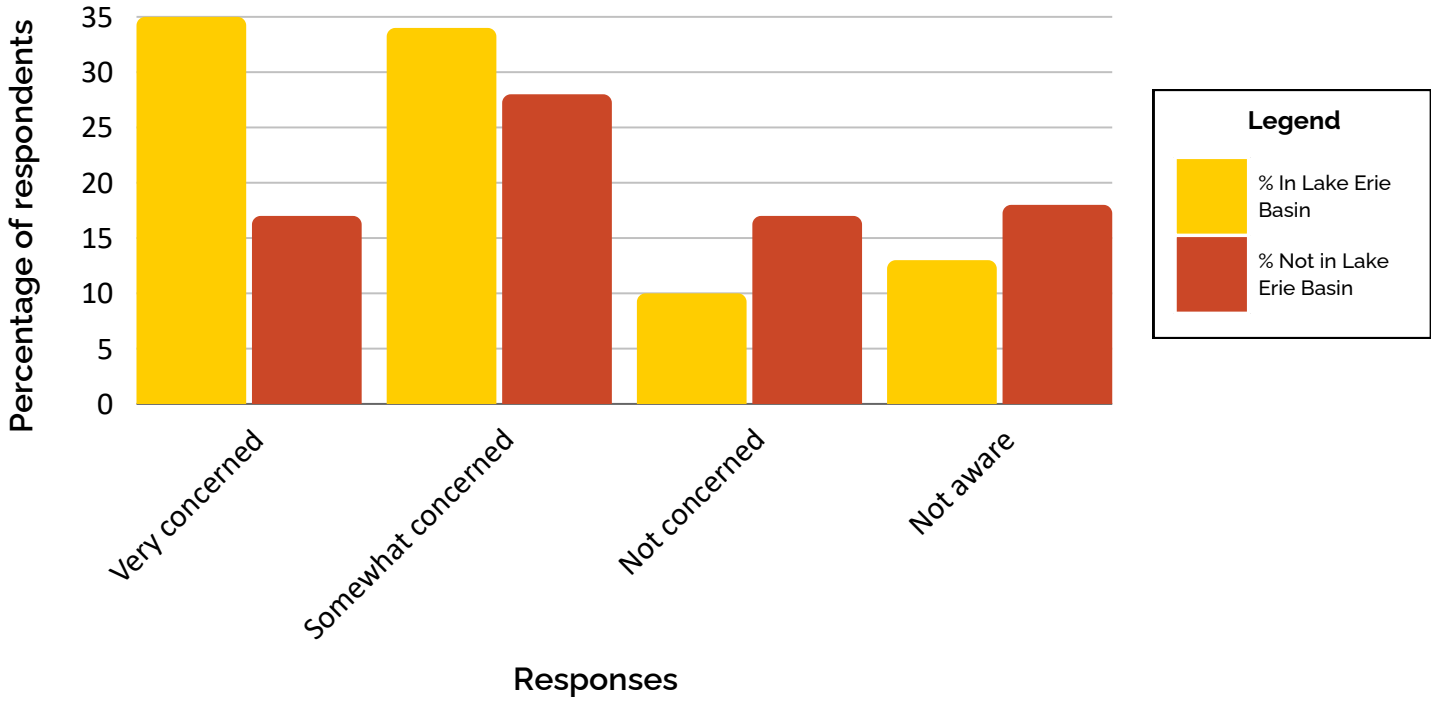


Figure 5. Percentages of survey participants in the Lake Erie watershed (n = 144) and outside of the Lake Erie watershed (n = 98) that selected each level of concern about the Lake Erie harmful algal blooms.

Livestock Farms

Concentrated animal feeding operations (CAFOs) in Indiana, Michigan, and Ohio are considered to be leading contributors to Lake Erie eutrophication. In 2022 there were approximately 400,000 cows, 1.8 million hogs, and 24 million chickens and turkeys within the U.S. Western Lake Erie basin (EWG, 2022). Livestock concentrations on the Ontario side of the Lake Erie basin are comparable (with the exception of poultry), even though the research suggests Ontario agricultural nonpoint sources of phosphorus (including manure) contribute only 10-30% of the total eutrophication in Lake Erie (ECCC, 2023).

In 2022, in the counties of Southern Ontario (not all of these counties completely drain into Lake Erie) there were approximately 340,000 cows, 1.5 million pigs, and 50,000 sheep, or 21%, 43%, and 16% of Ontario's total number of cows, pigs, and sheep, respectively (OMAFRA, 2024a). Although data for distribution of chickens and turkeys by Ontario counties are not available, poultry production on the Ontario-side of the basin is definitely lower than across the border, given that approximately 27 million were in production in 2022 across the entire province (Statistics Canada, 2022).

Over half (54%) of survey participants reported raising livestock (n = 134). Of these, almost half reported raising beef cattle (46%) or chickens (47%) (Figure 1). Sheep/goats and hogs were reported by 24% and 21% of livestock respondents, respectively, and 22% also reported raising "other" livestock types, including turkeys, geese, ducks, rabbits, alpacas, and horses. Only 16% of participants raised dairy cattle.

In addition to adherence to the Ontario *Nutrient Management Act* (see below), livestock respondents also reported practicing the following agricultural conservation practices. Almost half (46%) of the livestock farmers reported that livestock were rotationally grazed. About 61% indicated that they restricted livestock access to water features and 70% said there were buffer strips around at least some of the water features. Only 16% reported applying additional synthetic fertilizers to pasture.

A farmer observes his cows in the cowshed. (*Canva*)

Adherence to Ontario's *Nutrient Management Act* (ONMA), 2002

Ontario's *Nutrient Management Act* (ONMA) (2002) has been touted by the Great Lakes Water Quality Board as the manure management framework that ought to be the model for similar legislation in the United States, especially in jurisdictions where minimal to no regulations currently exist (GLWQB, 2019).[5]

There is little data verifying why Ontario's livestock operations contribute considerably less Lake Erie phosphorus overloading than their U.S. counterparts. This is somewhat surprising especially given that Ontario has comparable livestock numbers within the watershed. The ONMA, created in 2002 after seven people died of E.coli contamination from drinking contaminated water in Walkerton, ON two years earlier, may be the most compelling, if unproven, reason. Although the ONMA specifically states the number of livestock on a given farm cannot be restricted, the Act does regulate manure management for both storage (including distance from water features) and application (including a ban on winter spreading and the application of liquid manure via high-trajectory irrigation guns).

Under the ONMA, any livestock operations with more than five nutrient units (a calculation based on average nutrient values of livestock manure) that are applying for a building permit are required to write up a Nutrient Management Strategy (NMS), while those with over 300 nutrient units are required to have both an NMS and a Nutrient Management Plan (NMP). An NMS requires farmers to maintain records on the amount of manure generated, proof of adequate storage capacity, present a management plan for all runoff, and provide a sketch showing that all new facilities are at defined distances from all wells and water features. The additional NMP for larger operations requires further information on manure application in fields, tillage methods, and projected yields, etc.

The number of farm animals reported by survey participants were converted into Nutrient Units (NU), as defined by ONMA. This calculation allows for direct comparisons of different livestock, based on the typical nutrient levels in their manure.

Nutrient unit values calculated for livestock farms from the survey data ranged from 1-1555 (mean 98.1 ± 177.8 SD). Four-fifths (81%) of livestock farms had NU > 5, but only 35% reported having an NMS. Having the NMS requirement only for farmers who have taken out new building permits has meant that only a third of livestock farmers with NU > 5 who participated in this study have become directly subject to the ONMA. Approximately 8% of livestock participants had NU ≥ 300, based on their reported livestock numbers. The participant from our survey sample with the highest estimated NU (1555) shared that they did not have an NMP. **Almost half (over 47%) of survey respondents lacked an NMS or NMP.**

Livestock Manure Storage

The data suggests some slight trends between ONMA participation and manure storage and application practices. Approximately 61% of participants that lacked a NMS or NMP kept their manure in piles and only 16% stored it in a permanent structure. Permanent manure structures were more common among those with an NMS or NMP (38%), but even among these respondents an equal number (38%) stored their manure in piles. Similarly, of those livestock respondents who reported applying manure to frozen or snow-covered ground (n=17), approximately 65% were those without an NMS or NMP, compared with 29% of those who did.

Overall, 53% of all livestock farmers stored animal manure in a pile, and 40% shared that it was exposed to precipitation. Only 31% indicated that the manure was stored on an impermeable floor (e.g., concrete slab) and only 13% selected that the storage site was "covered". Less than one quarter (22%) reported that manure was stored in a permanent structure.

Respondents were asked if they knew the manure storage capacity of their operation (in months or days). Over 13% of respondents indicated that they were unsure of their storage capacity. Of those that knew, the most frequently selected storage capacity response option was for the largest capacity, "More than 365 days", with 28% of livestock farmers having selected this response. The next most frequent response was the smallest capacity, "Less than 6 months or 180 days", selected by 15% of livestock respondents. Only 31% of livestock participants indicated that they always fully empty their manure storage facility each time—a practice that is considered important for methane emissions reduction (Wood et al., 2014).

When asked if they would build new and/or secondary manure storage units if they had access to a subsidy or grant, 36% responded "yes", 36% replied "no", and 19% were unsure.

Manure Application

Approximately 61% of survey respondents (n = 150) reported applying manure to their fields. Most livestock respondents (87%) shared that manure produced by their operation was spread only on their own property. A minority (12%) said they sell their manure to neighbouring farms and only 2.2% shared that they sold their manure to contractors.

Manure was typically reported as a nutrient source on farms that had easy access to animal waste. Manure use was more frequently associated with livestock farms: 79% of livestock-only farms (n = 14) applied manure, while only 25% of field crop-only farms (n = 75) spread manure. Approximately 90% of mixed-commodity farms reported manure application (n = 128).

Just over two thirds (68%) of participants reported applying manure in solid form, while 11% applied manure in liquid form, and the other 19% applied manure in both liquid and solid form. Manure application methods were represented fairly equally: 30% reported broadcasting with incorporation into the soil, 31% without incorporation, while another 36% stated they employed both application methods. For farms that applied manure to their fields, manure ranged from 1-100% in meeting a farmer's nutrient needs, with a mean of 55.9% (± 34.2 SD).

Approximately 73% of livestock participants made decisions about manure use and application based on personal experience.

In spite of ONMA regulations deterring the application of manure in the winter on snow-covered or frozen ground, 13% of the participants who applied manure to their farm fields reported winter spreading. Of these, about 42% indicated that winter spreading was conducted "only when needed, but more than once" and that it was only ever done to create enough space in the storage tank to get to spring. A similar percentage (42%) indicated that applying manure on snow covered or frozen ground was a regular practice (yearly or multiple times per year). The reported amount of total on-farm produced manure spread on snow covered or frozen ground compared to the rest of the year ranged from 1-100% with a mean of 22.9% (± 24.3 SD).

Given that some negative nutrient management practices, like winter spreading, persist on livestock farms, **the NFU-O recommends better monitoring for risk-based compliance of livestock farmers under the ONMA**. Similarly, because preventative measures, like covered manure storage facilities or riparian buffer strips, have not been taken up by a

significant number of farmers, **we also advocate an increase in subsidies and cost-share programs to support livestock farmers, regardless of their size, to adopt leading manure conservation practices**.

Conventional Field Crops

By applying synthetic fertilizers (and occasionally manure or other fertilizer products), conventional field crops can contribute to the build-up of excess nitrogen and phosphorus in the soil and within a watershed. The Ontario side of the Lake Erie watershed has among the richest soil in the country, and it produces a tremendous amount of grain, most typically through a crop rotation of corn, soy, and winter wheat. Less than 1% of field crops across Ontario are farmed organically (OCO, n.d.). In 2022, the crop fields in the counties of Southern Ontario (not all of these counties completely drain into Lake Erie), were seeded with approximately 1.5 million acres of soy, 1 million acres of corn, and 360,000 acres of winter wheat, or 48%, 46%, and 39% of Ontario's total seeded acres of soy, corn, and winter wheat, respectively (OMAFRA, 2024b).

Most of Ontario corn, soy, and winter wheat is not grown for human consumption and the majority of the soy and wheat harvested is sold to export markets. According to a 2018 Grain Farmers of Ontario (GFO) report, less than one-quarter of the soy cultivated is for human consumption. Almost two thirds of the soy is grown for international markets, with three-quarters of the soy sent offshore to be processed into animal feed and/or non-edible oil products. Similarly, of the 31% of soy that stays in the country, over three-quarters ends up as animal feed, and another 16% is processed for oil (both edible and as biodiesel). The majority (90%+) of corn is used domestically, and more than half 54% is used directly (or as a processing by-product) for animal feed. Another 37% is processed as ethanol, alcohol, or oil. Only 18% is used to directly feed humans. Finally, just over half (57%) of Ontario wheat is used domestically. While use varies annually based on quality and market volatility, upwards to half ends up as animal feed, particularly for pigs or poultry (GFO, 2018).

Three quarters (75%) of all survey participants reported growing field crops, 82% of whom indicated they use conventional farming methods, i.e., they apply at least some synthetic fertilizers. Approximately 55% of conventional field crop farmers also used additional organic-based fertilizers, including non-agricultural source materials (e.g., human biosolids), 7.9%, mushroom compost, 5.9%, and on-farm and/or uncategorized compost, 5.9%.

Soy, corn, and winter wheat were the most commonly grown field crops, reported by 82%, 79%, and 68% of conventional field crop growers, respectively. A little over one-third (36%) cultivated hay or silage and 22% grew field crops other than corn, soy, wheat, and hay (Figure 1).

Synthetic Fertilizer Application

Unlike the application of manure or non-agricultural source materials (i.e. certain yard and vegetable waste, sewage biosolids, etc.) synthetic fertilizer application in Ontario is largely unregulated. The *Nutrient Management Act* (2002) does have setback requirements that ban application of any nitrogen or phosphorus within 100 metres from municipal wells. Synthetic fertilizer applications are also restricted within 13 meters of surface water, unless they are applied to a living crop or applied to soil with at least 30 percent crop residue or they are injected, banded, or incorporated into the soil during or 24 hours

after application (ONMA, O.Reg 267/03). Beyond these restrictions, there is no legal limit to the quantity of synthetic fertilizers that can be applied on non-greenhouse agricultural operations.

The Ontario Ministry of Agriculture, Food and Rural Affairs provides general guidelines for nutrient application rates, based on soil test results (OMAFRA, 2017). It is advised that these guidelines be used as starting points in determining appropriate rates, and should be adjusted based on a variety of contingent factors, including previous manure and fertilizer applications, crop rotation, soil type, application method, weather, and price ratios. Very few respondents indicated awareness of OMAFRA's guidelines. **Half (50%) of conventional crop farmer respondents said they rarely or never use or follow OMAFRA's Nutrient Management Software Program (Agrisuite) or their recommended rates to help assess their on-farm nutrient requirements, and another third (33%) said they were not even familiar with Agrisuite.**

The data in the corn, soybean, and winter wheat fertilizer trends that follow are not definitive. Application rates are highly variable and are dependent upon a number of contingent factors and should be based on regular soil sampling. **Anywhere from 18% to 33% of conventional crop farmers (n = 152) were unaware of their approximate yearly application rates of nitrogen and/or phosphorus.** Although the data is inclusive, the farmers who did report typical nitrogen and phosphorus application rates typically fell within the mid to high-range of OMAFRA (2017) recommended rates based on soil sampling.

Corn Fertilizer Trends

For those conventional corn growers that reported their N application rate (n = 70), over half (56%) applied nitrogen in excess of 181 kg/ha. Almost 20% indicated they apply synthetic nitrogen at approximately the maximum rate recommended by OMAFRA (2017) (211 kg/ha N for corn) based on the lowest level of nitrate-nitrogen (1 ppm) measured from spring soil samples. Another 11% of participants reported applying 221 kg/ha or more N. **In all, almost one in three conventional corn growers indicated they apply at or above OMAFRA's maximum recommended synthetic nitrogen rate.**

Of the conventional corn growers that reported synthetic phosphorus (as phosphate, P_2O_5) rates for conventional corn crops (n = 50), 31-45 kg/ha phosphate was the most frequently represented range category, selected by over 22% of conventional corn growers. This falls roughly in the mid-range of rates recommended by OMAFRA (2017) wherein sodium bicarbonate phosphorus soil tests are found to be at or above 12 ppm. Approximately 42% indicated that they apply over 60 kg/ha phosphate, the amount recommended for soil tests measuring P at or below 12 ppm.[6]

Soybean Fertilizer Trends

Because soybeans actually fix nitrogen, using synthetic nitrogen fertilizers is not usually recommended for their cultivation (OMAFRA, 2017). In rare cases where there is evidence of nitrogen deficiency in a soybean crop, OMAFRA (2017) recommends applying 50 kg/ha (45 lb/acre) of N as a remedial measure. Just under 80% of conventional field crop farmers did not apply nitrogen to their soybean crop. However, almost 13% of conventional soy crop respondents

reported applying nitrogen to soybeans. Almost a quarter of soy growers that reported their phosphate application rate indicated that they applied 35 kg/ha P_2O_5, falling in the mid-range of rates recommended by OMAFRA (2017) wherein sodium bicarbonate phosphorus soil tests are found to be near 12 ppm. Less than 4% reported applying 41 kg/ha P2O5 or more.

Wheat Fertilizer Trends

Almost 50% of conventional winter wheat growers that reported their N rate (n = 61) selected the 111-135 kg/ha N range response option and 36% indicated they applied over 135 kg/ha N, which lies in the high range of OMAFRA (2017) suggested nitrogen requirements. OMAFRA also advises against nitrogen application to winter wheat in the fall as over 50% of the nitrogen will be lost over the winter.

Of the conventional winter wheat growers that reported phosphate application rates (n = 41), almost 42% reported applying 41 kg/ha P_2O_5 or more, which falls within the mid to high range of OMAFRA (2017) recommended rates based on soil samples.

Best Agricultural Conservation Practices for Soil & Water Health

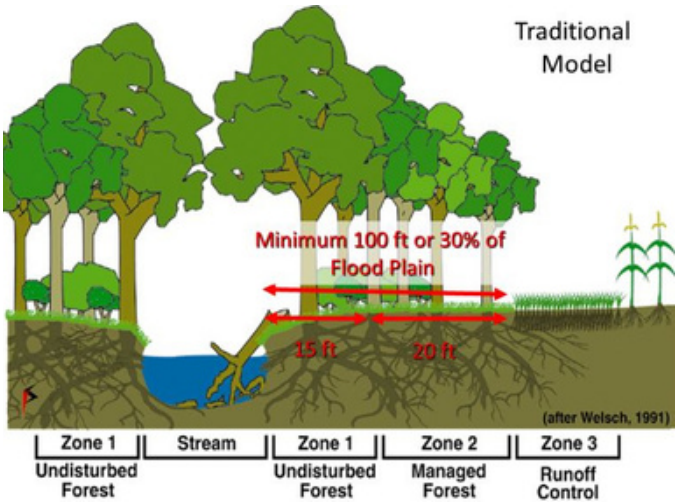
There are two different categories of agricultural conservation practices that help to support healthy soils and watersheds (Fraker et al., 2023).

The first, nutrient management, is typically referred to as 4R Nutrient Stewardship. First introduced by industry, 4R Nutrient Stewardship is a voluntary approach that encourages the right place, rate, time, and source of nutrient application. While efficiency is often touted as a rationale for the 4Rs they are often conflictingly promoted as a means for maximizing production. As the NFU has argued, so long as efficiencies are tied to maximizing yields, the 4R approach can perversely lead to an increased use of fertilizers, even though increasing application has shrinking returns and offers little financial benefit to farmers themselves (Qualman & NFU, 2022).

Aside from the need for the 4Rs to be delinked from yield maximization, **regular soil testing is the foundation upon which any successful 4R nutrient stewardship depends** (International Plant Nutrition Institute, 2016).

> ***By grid sampling and variable rate nutrient application we have greatly reduced the amount of fertilizers we use.***

– Farmer Survey Respondent



Riparian buffers are planted along water bodies to prevent pollutants from agricultural runoff to enter the water table. (Zomora & Wyatt, 2020)

The second set of agricultural conservation practices recommended by farmers and agricultural experts consists of a variety of soil and water control practices, including runoff and erosion control (filter strips, field borders, riparian

buffers, hedgerows, woodlots), cover cropping and crop rotation, residue tillage management, and drainage water management, including controlled tile drainage.

In addition to reporting fertilizer rates, conventional and organic crop farmer respondents also shared how they engaged in a variety of best practices, including the maintenance of soil cover, fertilizer timing and application methods, and soil testing. Understanding how farmers understand the practicalities and realities of 4R Nutrient Stewardship (right source, rate, time & place) is an important first step in determining what kinds of soil health practices might successfully reduce nutrient use.

The following sections report on respondent adoption and practice of these key best agricultural conservation practices.

Soil Testing Frequency

Approximately 57% of respondents indicated that they conduct soil testing for baseline nutrient levels every 1-3 years. This is higher than Statistic Canada's 2020 data that reported that 36.4% of Ontario farms reported soil sample testing (Zong, 2022). Over a quarter (27%) also grid sample soil to test for nutrients every 3-5 years. OMAFRA (2017) suggests that analyzing soil samples for nutrient levels once every three years should be adequate for understanding the nutrient requirements for most farms. **Approximately 15% of respondents indicated that they have never had their soil tested for nutrient levels and 22% indicated that they do not test their soil at least once every three years, as recommended.** In other words, more than one in three farmers surveyed did not voluntarily soil test according to OMAFRA recommendations.

In spite of the fact that soil testing can actually help farmers determine lower fertilizer application rates, thereby realizing input cost savings, many are dissuaded by the actual cost of these tests. **Free soil testing via publicly funded extension services is really a baseline requirement to support nutrient reductions.**

4R Nutrient Stewardship Adherence

For the purposes of this study, 4R Nutrient Stewardship is understood as what is sustainably and ecologically "right" by encouraging farmers to use nutrients at the *right* time (as close as possible to maximum crop uptake), *right* placement (subsurface banding over surface spreading), *right* source (maximize use of enhanced efficiency fertilizers which employ coatings and/or nitrification and/or urease inhibitors), and *right* rate (which includes regular soil testing to calculate nutrient balances and setting rates based on average, not maximum yields). Industry may have developed the idea of 4R Nutrient Stewardship but it is time that the farmers committed to soil and water health, not fertilizer companies, decide what is meant by "right."

The time of year that conventional field crop farmers reported applying synthetic fertilizers was variable, as some commented that it depended on the type of crop. Spring planting was the most frequently selected time (69%). Approximately 38% reported applying synthetic fertilizers in split applications, 42% reported using side banding, mid-row banding, or seed-placed application methods, and 30% indicated that three-quarters of their synthetic nitrogen is applied during spring planting. Banding and seed placing is widely considered one of the most important actions to reduce nutrient loading (Wilson et al., 2019).

Most conventional field crop respondents indicated that they regularly follow the 4Rs of nutrient stewardship: 42% and 39% responded "always" and "usually", respectively, and 52% said that they never apply fertilizer above the recommended rate as a risk mitigation strategy to help attain crop yield targets.

Some respondents also shared that they found it challenging to find and access specific guidelines on how to follow the 4Rs of nutrient stewardship without completing Fertilizer Canada's 4R Nutrient Stewardship Certification Program. **What is *right* for the fertilizer industry, is not necessarily what is *right* for farmers or what is *right* for the soil or watershed. We need a farmer-led, publicly-funded 4R Nutrient Stewardship program that regularly updates agriculturalists on the best application practices.**

Soil & Water Control Practices

There are a myriad of soil and water control practices that have been acknowledged by farmers, scientists, and industry experts as useful agricultural conservation techniques that can protect the short and long-term health of soil and water (Figure 5).

However, little work has been done to quantify the "particular effectiveness at reducing phosphorus loading associated with each practice" (LimnoTech, 2022). An Ontario Federation of Agriculture (OFA) initiative, the Thames River Phosphorus Reduction Collaborative, was working for several years to rectify this knowledge gap by installing farmland testing technologies for phosphorus, but it has since folded. More recently, the Healthy Headwaters Lab through its Farm & Freshwater Ecology Research Network (FERN) at the University of Windsor has been working with a farmer advisory board to study the effectiveness of sustainable agricultural practices.

There are also disagreements and competing opinions about which practices should be prioritized and/or how to best foster adoption. For instance, while many continue to tout the value of no-till and/or conservation tillage as part of any nutrient management strategy, recent research on soluble phosphorus is suggesting that incorporating fertilizer into the soil via tillage or subsurface injection may reduce phosphorus loss better than no-till/conservation options (Tiessen et al., 2010; Ulen et al., 2010; Wilson et al., 2019).

In addition to the 4Rs, the two other agricultural management practices most widely touted involve: 1) Erosion controls, particularly through tillage methods, maintaining soil cover, and by introducing filter strips, hedgerows, grassed waterways, etc.; and 2) Drainage water management techniques, (like controlled tile drains) that limit the amount of water leaving a field (Wilson et al., 2019).

Most field crop participants indicated that they engaged in many of the best agricultural conservation techniques (Figure 6).

Crop rotation was the most commonly selected practice and regular surface water and/or well water testing for nutrients was the least frequently selected.

Vegetated buffer strips or riparian buffer strips were reported by a majority (56%), as were wind breaks (59%). According to Statistics Canada, in 2014, wind breaks or shelterbelts were present on little more than a quarter of Ontario farms and riparian buffer strips on only 23%. A recent study by Michael Drescher with the University of

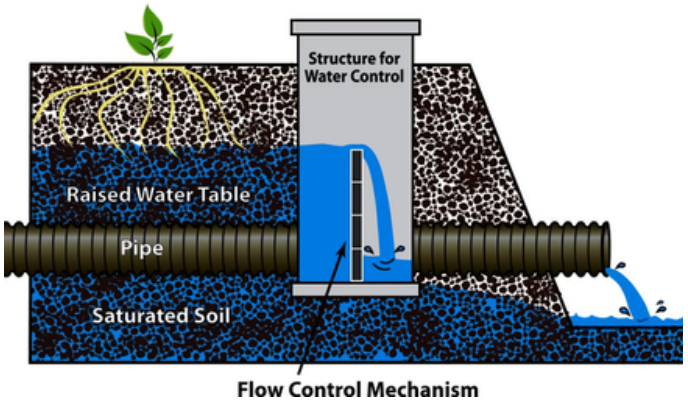
Waterloo found that farmers are concerned that their neighbours are regularly removing riparian buffer strips, windbreaks, and woodlots. Removing these features may allow farmers to bring in larger machinery and increase their field size. But, Drescher warns, maximizing a field's size may not correlate to greater yields as larger equipment tends to compact the soil and the ecological features removed help to protect against soil erosion (Drescher, 2023).

No-till/zero tillage was the most frequently reported tillage method (selected by 45% respondents), followed by conservation tillage (42%) and conventional tillage (41%). Few respondents selected rotational tillage (13%) or strip tillage (3%) (Figure 6). As mentioned, there is some dispute about the benefits of no-till practices on nutrient loss, but strip-tillage alongside deep-band application of fertilizer for corn (but not soy) operations has been proven to both improve yields and help prevent phosphorus off-loading (Preston et al., 2019).

It is recommended that at least 30% soil cover be maintained 100% of the time on crop fields to help prevent soil erosion and nutrient loss (OMAFRA, 2017). To help maintain this cover, OMAFRA suggests there should be at least 50% crop residue left on the fields going into the fall. Over half of conventional corn and soy crop growers reported leaving over 50% crop residue (58% and 73%, respectively). Fewer (37%) reported leaving > 50% crop residue for winter wheat, likely because it is common for farmers to remove dried wheat straw for livestock bedding.

While the majority of field crop respondents had tile-drained fields, little more than one in ten (11%) used control tile drainage structures near outlets to restrict flows during certain times of the year. Sunohara et al., (2016) in a study conducted in eastern Ontario found that controlled tile drainage "is effective in reducing daily tile discharge" of all nutrients and fecal matter by two-thirds or more compared to uncontrolled tiled fields, and can even boost crop yields by modest amounts of 3% or more. One of the biggest barriers to the adoption of this management practice, suggest the authors, is the labour required to adjust control tile "stop logs" up to four times a year and automated systems remain cost-prohibitive. They also suggest another disincentive is the lack of extension service support to guide the installation and use of controlled tile drainage systems (Sunohara et al., 2016).

Over half of our survey respondents (55%) indicated that they were aware of the potential benefits of the practice of controlled tile drainage to crop yields by keeping moisture in fields during the growing season and increasing drought resilience. More than half (59%) also responded positively to the idea of learning more about controlled tile drainage. Based on its demonstrated benefits, **controlled tile drainage is a practice that deserves wider adoption**.



Controlled tile drainage helps to control the amount and timing of water leaving agricultural fields through tile lines. (NRCS, 2013)

Figure 6: Best nutrient management practices farmers reported practicing

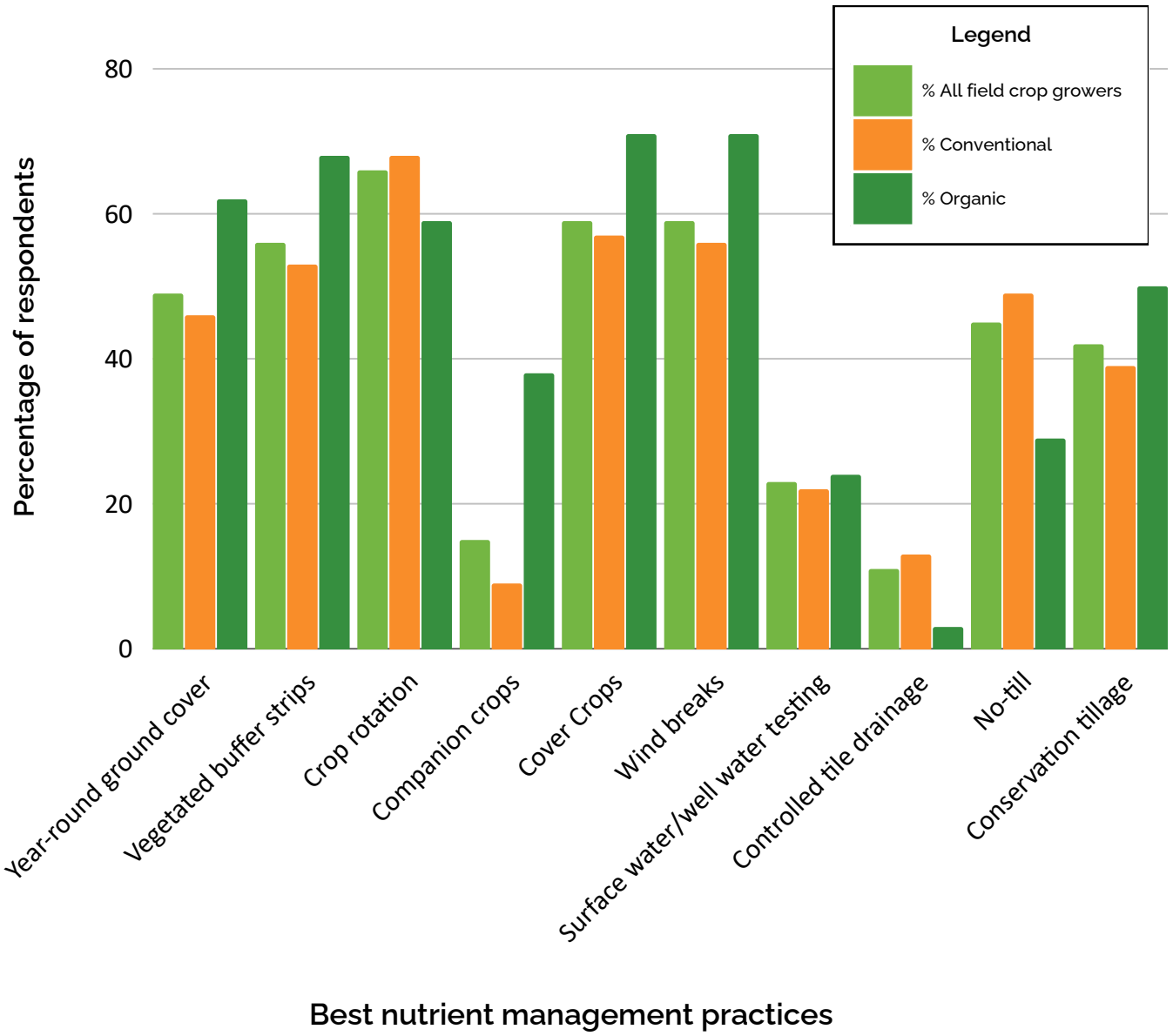


Figure 6. The percentages of all field crop growers (n = 185), conventional growers (n = 152), and organic field crop growers (n = 34) that reported practicing each best nutrient management practice.

Where Farmers Learn Agricultural Conservation Practices Matters

Most conventional crop farmers are not learning about nutrient management, be it timing, application rates, or conservation methods from OMAFRA or public agrologists. Less than 12% of conventional field crop farmers "always" or even "sometimes" followed OMAFRA's nutrient management guidelines and only 9% used OMAFRA's Corn Nitrogen Calculator to help assess nutrient requirements.

Similarly, our survey data provokes questions as to whether the current voluntaristic approach to the dissemination of agricultural conservation practices is enough. For instance, very few registered awareness of Farmers for Climate Solutions' FaRM resilience mentorship program. Only 12% had applied for the federal On-Farm Climate Action Fund, 7% had applied for Ontario Soil & Crop Improvement Association (OSCIA) grants under the Canada-Ontario Environmental Farm Plan, and only one respondent availed themselves of ALUS Ecosystem Services (for more on grant participation, see below).

Environmental Farm Plans (EFPs) have been around since the early 1990s after farmers voluntarily decided to incorporate environmental concerns into agricultural production practices (Robinson, 2006). Administered in Ontario by OSCIA, these voluntary planning tools help farmers identify ways they can improve and/or implement action plans to achieve a variety of agricultural conservation measures. Farmers with EFPs are often invited to local workshops and have access to, mostly federal, cost-sharing programs administered by the OSCIA.

Unfortunately, participation rates in EFPs have remained low and uptake varies across agricultural types and locations. In Ontario, the total number of EFP participants dropped from 46% in 2017 to 42% in 2021 (Statistics Canada, 2023). In 2021, over one-third (36%) of those with EFPs had done so more than 5 years ago and there is no formal or required reapproval process. Only 10% to 20% of the estimated 50,000 Ontario farmers participate annually in the EFP program, falling stubbornly below the Ontario Biodiversity Council (OBC) target of 25% (OBC, 2021).

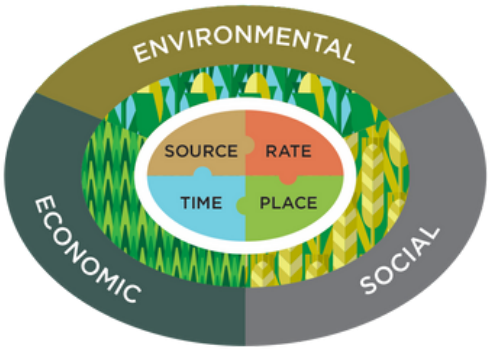
Still, over 27,620 on-farm environmental projects have been completed via EFPs between 2005-2020. In the Lake Erie basin, Chatham-Kent county boasts some of the highest numbers of completed projects, whereas considerably fewer farmers in Norfolk and Haldimand counties have participated (OBC, 2021). Participation could be even higher, suggest advocates, if there were greater financial incentives (Chalifour and McLeod-Kilmurray, 2016). Financial incentives, including cost-share programs and/or specialized agricultural conservation tax rates are discussed below.

While most farmers appear to have had some exposure to voluntaristic agricultural conservation programs, the vast majority rely predominantly on personal knowledge and/or advice from corporate fertilizer producers to determine their nutrient needs. Over 87% of conventional field crop farmers (n = 152) said they made decisions about synthetic fertilizer use (e.g., which types of fertilizers to use and application rates), based on advice from a professional crop adviser/agrologist. Almost two-thirds (63%) reported that their advisor/agrologist is associated with an agri-retailer, dealer, or manufacturer. More than half (54%) said they also rely on personal experience when making decisions about fertilizer use.

One American study found that the 4R Nutrient Stewardship Certification Program that has certified private advising companies and agronomy retailers in several US States as well as Ontario and P.E.I. has had "at least to some degree" a positive effect on 4R behaviors and that farmers already trust these entities (Walpole et al., 2023). However, this study failed to examine the reality that fertilizer retailers, even after following the certification program, are in the business of selling fertilizers and have little incentive to sell less. Nor did they explore why farmers trust these retailers and whether they would continue to do so if there were free and public alternatives. A Canadian Agri-Food Policy Institute's 2023 study also recorded that farmers generally trust crop input retailers and that university/government extension services are perceived as less reliable, but it too did not explore retailer conflicts of interest or the fact that in many regions, including Ontario, public extension services are no longer being funded (McCann & Lika, 2023).

While the majority of our respondents believed the professional advice they received was always or usually in their best financial interests (69%) and environmentally sound (70%), that still left almost 30% of conventional crop growers who believed their advisors, only sometimes, rarely, or never put the farmer or environmental interests first. Fertilizer sales people "are always trying to sell more than you need," said one respondent, while another argued that so long as "maximizing yield is the number one goal then the advice will always put the environment as secondary to that goal." More than one respondent shared that they believe private fertilizer advisors recommend application rates beyond what is required.

Raising awareness among farmers about best nutrient management practices is clearly important, but the voluntaristic approach is proving no match for the financial costs associated with widespread adoption, or the self-serving education being pumped out by corporate fertilizer interests.



The 4R's of nutrient management: right source, right rate, right time, and right place. Implementation of the 4R's helps to align the economic, environmental, and social components of nutrient management. (International Plant Nutrition Institute, 2016)

Barriers to Adopting Best Agricultural Conservation Practices

All survey participants were asked to select what they believed to be the biggest impediment to the adoption of best agricultural conservation practices from a list of potential barriers. Cost/expense was identified as the #1 barrier to adopting best nutrient management practices by 27% of survey participants, while 12% believed a lack of available incentives was the #1 barrier restricting wider adoption of BMPs. Lack of independent, non-agri-retailer information/knowledge and lack of perceived benefit were identified as the #1 barrier by 13% and 12% of respondents, respectively. When asked to identify additional barriers from the same list, cost/expense (23%) and lack of incentives (22%), such as grants, cost-share programs, etc. topped the list (Figure 7).

Figure 7: Barriers to adopting best management practices

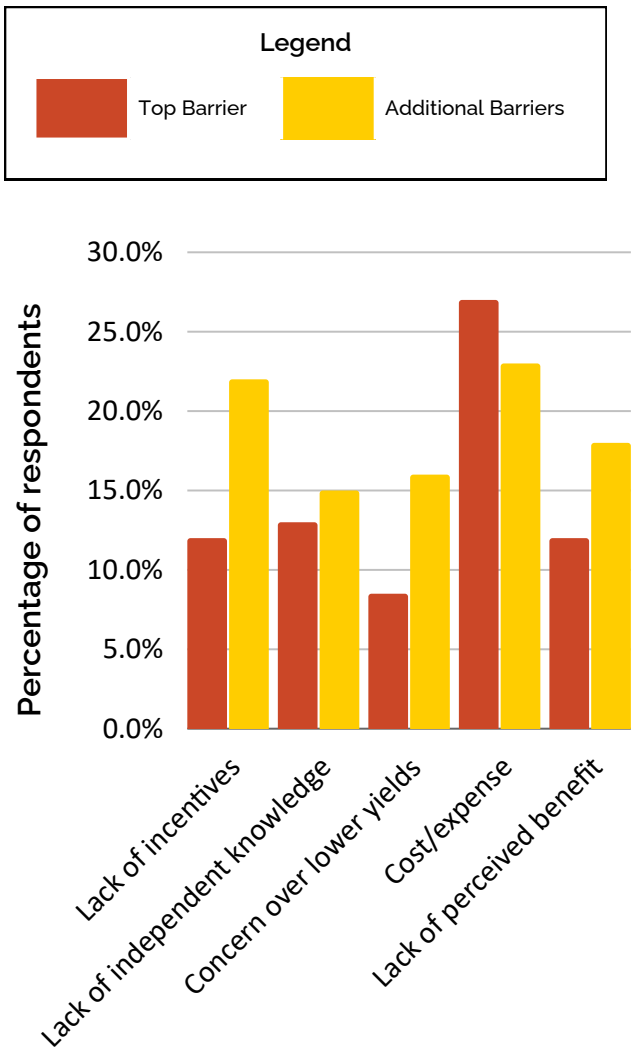


Figure 7. The percentage of nutrient management survey respondents that selected each barrier to adopting best management practices.

The existing literature repeatedly points to the fact that financial incentives, regulatory requirements, or a combination of both are needed to overcome the cost/expense barrier of adoption. Small farms could "benefit especially from subsidy programs that offset a large share of the labor costs for the adoption and maintenance of best practices," reports Michael Drescher (Drescher, 2023). While low-cost and easy to implement practices can be quickly taken up by farmers, higher-cost practices, for instance, cover crops and/or removing certain sensitive areas out of production, are unlikely to be voluntarily taken up if they are not perceived to provide net financial benefits to the farmer (Drescher, 2023; LimnoTech, 2022).

Funding Supports to Improve Agricultural Conservation Practices

In 2015, Canadian federal expenditures on conservation practices in agriculture, "as a share of farm income, [were] more than 10 times smaller than that of those in the US and EU" (Eagle et al., 2015).

Given that costs and/or a lack of incentives topped the list of barriers to implementing best nutrient management practices, it came as some surprise that only 15% of survey participants reported that they applied for grants, cost-share programs, or subsidies in the past 10 years to support improved management of farm nutrients. Of those, over 79% shared that their applications were successful.

Almost half a billion dollars was invested in on-farm conservation improvements through OSCIA-administered Environmental Farm Plan (EFP) programs between 2005-2020 (OBC, 2021). A 2010 sample survey reported that on-farm improvements cost an average of almost $70,000 per farm, with less than one-quarter covered through government cost-share programs (Smith et al., 2020). Currently, EFP environmental projects are eligible for cost-share funding through the $3.5 billion Sustainable Canadian Agricultural Partnership (SCAP). Through SCAP, the Ontario and Canada governments are providing $68 million to support three programs under the Ontario

Agricultural Sustainability Initiative (OASI):

- Resilient Agricultural Landscape Program (RALP) - $56.7 million to fund projects to reduce tillage, create water retention ponds and other projects designed to either reduce GHGs or sequester carbon.
- Agricultural Stewardship Initiative (ASI) – $5 million to modify or adapt equipment or operating practices.
- On-Farm Applied Research and Monitoring (ONFARM) - $7 million to support education and communication to promote best on-farm practices related to soil and water health.

Over half of survey participants indicated they would consider applying for agricultural conservation improvement grants/subsidies and another 35% said "it depends." A number of farmers shared that they do not have time to look for information on what programs are available and/or don't know where to look. Frustrations about current and past grant/subsidy programs were shared by a number of respondents. These complaints included:

- tedious and overly onerous application process;
- unfair grant requirements where only large operations can afford to hire professional grant application writers;
- previous grants were perceived as doing little to protect the environment and were limited to technological improvements;
- grants do not reward farmers who have independently made nutrient management improvements and adopted best practices on their farm; and
- grant programs are not long enough to encourage late adopters.

Said the farmers:

> ***You know if you're going to try something new, you could get hurt. There should be more incentives and support for farmers to try something new.***

> ***The application process has to be simple. I'm tired of all the time and work it takes, and frustrated seeing big greenhouses hire people able to write an application. It shouldn't be based on how well you can write an essay.***

> ***A lot of these programs are very good, but the level of detail and effort required make most people not even want to attempt applying for them. The frustrations with the paperwork are a huge barrier which even affects farmers' mental health.***

> ***Many programs have a lot of prerequisites requiring workshop attendance and an environmental plan. The need to do some of the workshops was too much. Also, many of the opportunities are cost-share, so you have to spend a lot of money and will maybe get half of it back. The ask is too much for what you get in return.***

Confronting High Input Costs and the Fertilizer Oligopoly

Fertilizers are a significant input cost for crop farmers. OMAFRA estimated that, in 2023, conventional corn farmers would spend upwards to a third of their total input costs on fertilizer; soybean farmers would lay out 20-23%, and winter wheat farmers almost 40% of their total input costs on nutrients. In fact, fertilizers are the single highest input cost across all three commodities (OMAFRA, 2023).

Conventional field crop respondents were asked to estimate the percentage of their operating costs spent on synthetic fertilizers. Estimates ranged from 0-75% with a mean of 23.2%, (± 17.0 SD).

Fertilizer costs have been volatile and on the rise. According to Farm Credit Canada, nitrogen fertilizer prices increased by 148% between 2020 and 2023 (Lika & Mussell, 2023). To quiet alarm, some researchers promised that increases in commodity prices meant that most corn crop farmers with average yields "would be able to safely navigate high fertilizer prices and remain profitable in 2022" (Bannon, 2022). While this might assuage some, there is no consoling farmers to the fact that the fertilizer oligopoly, on one side, and the commodity buyers, on the other, consistently gouge into their ever-diminishing profits.

Just four fertilizer companies (Nutrient Ltd., CF Industries, Koch Fertilizer, and Yara) hold 95%+ of fertilizer production in Canada (Qualman & NFU, 2022). When one of these companies cuts production, they can affect prices. During the early twenty-first century corn price boom (buoyed by the ethanol craze) fertilizer prices rose quickly, but only dropped in cost during the post 2012 bust when farmers' pocketbooks were already tight. Fertilizer companies, and other input suppliers, capitalize on the cyclical nature of agricultural returns, squeezing farmers at every downward and upward turn, leading Chad Hart, an Iowa State University economist to declare that "the long run profitability" for farmers in such a competitive industry "is zero." (cited in Philpott, 2020).

> ***The challenge is that it's very difficult to farm for profit without farming for yield, because without a high yield it limits your profitability. However, at the end of the day I agree I would rather farm for profitability over yield.***
>
> **– Farmer Survey Respondent**

The NFU's report on the Canadian fertilizer context confirmed that, more than any other factor, fertilizer prices are linked to the oligopoly profiteering of a handful of fertilizer companies who have consistently increased profits when demand is high. The best way to challenge such corporate power, the NFU suggests, is to collectively decrease demand by getting off the "yield-maximization treadmill" (Qualman & NFU, 2022).

In 2021, when the federal government announced the goal of a 30% reduction in emissions for on-farm fertilizer use by 2030, Fertilizer Canada cried foul claiming farmers would lose $48 billion in income due to yield loss (Fawcett-Atkinson, 2022). Oligopoly profits and farmers' incomes are not the same thing. NFU farmers have pushed back against Fertilizer Canada to expose the fallacy that

"defending fertilizer" is somehow the same as "defending farmers." Farmers don't benefit from maximum fertilizer application, they "prosper when they use only as much as necessary" (Qualman & NFU, 2022).

> ***I've noticed the disconnect between yield and profit—consumers see a value in something grown sustainability and are willing to pay more for it. By growing sustainably, I'm producing commodities associated with lower yields but higher value.***
>
> **– Farmer Survey Respondent**

Survey respondents did report that they do try to limit fertilizer use because of the high cost. One respondent said he applies fertilizer at 20% less the recommended rate to save money. Another said, however, that he would apply above the recommended rate if fertilizer was cheap, and used to when it was.

Many participants also responded favorably to the concept of "least cost crop production" (Figure 8). Coined by one of our agricultural advisors, least cost crop production is the adoption of any production practices that serve to reduce synthetic nutrient inputs without a corresponding reduction in farm profit. Approximately 42% were interested in learning more about reducing input costs, 24% maybe, and only 20% said no, with the remaining 9% unsure. Compared to the conventional field crop respondents, slightly higher percentages of organic field crop farmers indicated they were interested in learning more about least cost crop production and fewer responded no.

When asked how they would respond to the statement, "I would prefer to farm for profit, not for yield" 63% of all field crop respondents indicated that they agree with the statement, while only 4% disagreed with it and 28% indicated that they neither agreed or disagreed with it.

Figure 8: Farmers interest in learning about "least cost crop production"

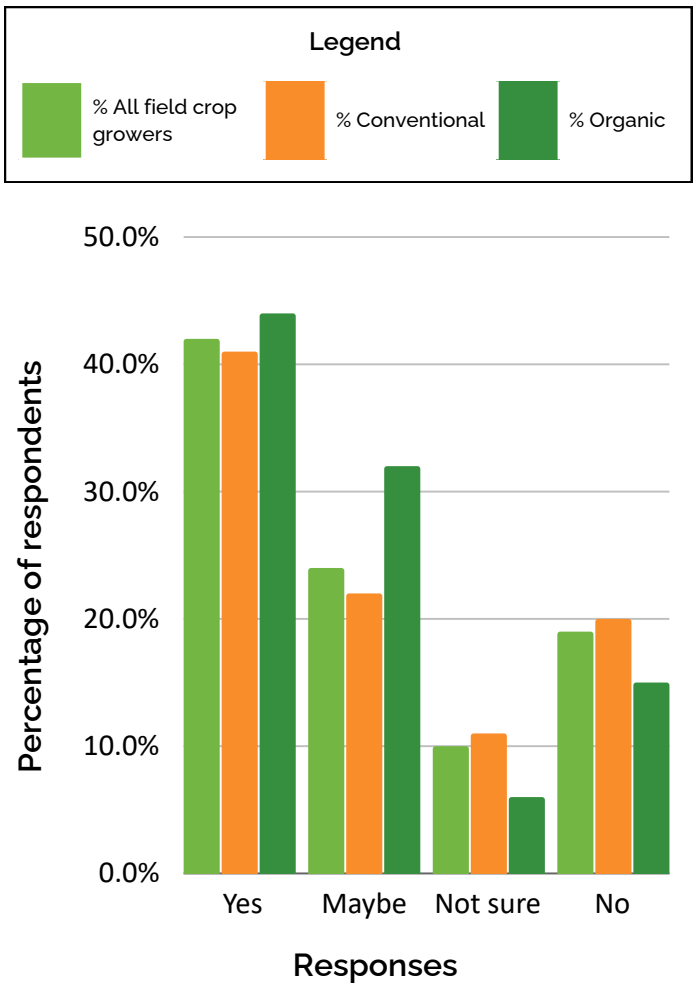


Figure 8. Responses to the question about interest in learning how to implement "least cost crop production" from all field crop growers (n = 185), conventional growers (n = 152), and organic field crop growers (n = 34)

Darrin Qualman, the NFU, and Farmers for Climate Solutions have challenged farmers to understand that the reasons to step "off the yield-maximization" treadmill "go *far* beyond the environmental." Yield chasing gluts the market only to suppress prices and increasing demand for fertilizers and chemicals only encourages corporate suppliers to hike prices and realize greater profits (Qualman & the NFU, 2022). Instead of getting trapped in the erroneous perception that increased yields = increased margins, Qualman encourages farmers to ask the question of whether current fertilizer uses "maximize net benefits." Farmers, Qualman suggests, should collectively "embrace limits"—doing so is "a doorway to liberation, sovereignty, and self-determination" for farmers currently beholden to corporate capture (Qualman & the NFU, 2022).

> ***Ideally, we would all be farming for profit and improving the soil and ecosystem.***

– Farmer Survey Respondent

Exploring Nutrient Management Cross-Compliance and Regulatory Measures

When it comes to nutrient management on crop operations, many researchers assert that the current voluntary, incentive-based approach to encourage best management practices is inadequate and that some regulation or disincentives, such as linking government incentive/subsidy/insurance policies to conservation compliance, will be necessary (Scavia et al., 2014). Some climate-change models suggest that adoption rates of best practices will need to exceed 80% in any given region to effectively reduce HABS in a watershed, a level of adoption that is unlikely to occur without some degree of regulation, especially for practices that most farmers deem as cost-prohibitive (Fraker et al., 2023).

If voluntary adoption of the best nutrient management practices for soil and water health is important but insufficient on its own, what are the alternatives and are farmers willing to explore them?

One promising avenue to support wider adoption of agricultural conservation practices that came up in respondent discussions and the literature, is linking current tax-breaks/incentives/programming to proven on-farm ecological improvements.

Agricultural Conservation Cross-Compliance

Canadian policy makers have toyed with the idea of cross-compliance since the 1990s, but, so far, the only Canadian cross-compliance measure falls under the Quebec Agricultural Operations Regulation, 2002, which requires hog operators to produce a yearly phosphorus report. Failure to comply can lead to exclusion from farm insurance programs (Rude & Weersink, 2018). Cross-compliance between agricultural support programs and ecological improvements have been proven to be successful in both the United States (for soil erosion) and Europe (soil management, retention of landscape features, pasture maintenance, nitrogen and phosphorus discharge, etc.). European measures tend to focus more on monitoring whereas the U.S. model relies on penalties to spur compliance (Rude & Weersink, 2018; Follador et al., 2011; Herzog et al., 2008).

Chalifour and McLeod-Kilmurray (2016) suggest that sustainability criteria should be written into all federal agricultural programs and services offered through Agriculture and Agri-Food Canada as the bulk of the current policy is geared to increasing market share and innovation rather than "supporting environmentally sustainable farming practices."

Farmers for Climate Solutions has called for an incremental revamping of federal Business Risk Management programs, like AgriInsurance, AgriInvest, and AgriRecovery to incentivize crop rotation and the adoption of agricultural conservation practices, and disincentivize practices that convert grasslands, wetlands, and tree cover to agricultural production and/or that are known to increase GHG emissions (De Laporte et al., 2022). Scholars have argued that for such cross-compliance to be effective, AgriInvest incentives would have to be increased if the goal is to receive substantial buy-in from farmers (Rude & Weersink, 2018).

Another promising provincial/municipal cross-compliance option, suggested by one of our survey respondents, would be to make ecological improvements a condition for farmers to either receive the full 25% agricultural property tax rate (the current tax rate farmers receive through their farm business registration) or introduce a further reduced conservation tax rate of less than 25% for those who adopt specific agricultural conservation practices.

Agricultural Conservation Regulatory Policy

Regulatory policy is another potential solution. Each field crop grower (conventional and organic) was asked their opinion on the idea of expanding Ontario's *Nutrient Management Act* (2002) to require nutrient management regulatory standards for the use of synthetic fertilizers. Somewhat surprisingly, **47% of survey respondents responding positively to regulation and only 37% negatively**. There was no appreciable difference between organic and conventional growers in favour of regulation, although fewer organic producers responded negatively to the idea compared with conventional farmer respondents (Figure 9).

Regulations are so rarely talked about within the agriculture sector, in part because fertilizer lobbyists, like Fertilizer Canada, have effectively shifted farmer angst around having their profits squeezed between high input costs and low prices in the commodity markets to the bugbear of government regulation; this is true even when governments have mostly shied from anything but voluntary measures, as they did when they announced in 2021 the goal of a 30% reduction in emissions for on-farm fertilizer use by 2030. Why should farmers let fertilizer companies tell them what is good for them? It's time to take pause before a knee-jerk reaction against proposals for farmer-informed regulatory standards.

It takes some sleight of hand to convince farmers that the real cause of their year over year decline in earnings is the cause of regulation. Take Ontario's current *Nutrient Management Act* as an example. While there is a paucity of studies actually verifying the effectiveness of the ONMA's livestock manure regulations, the University of Guelph churned out a half dozen theses or more on compliance costs on dairy, laying hen, pig, and other livestock operations since the Act's introduction.[7] The majority of these studies found that compliance costs were low to non-existent, especially when operations adopted optimal best practices.

If we are so concerned about farmers' bottom lines (and we should be), why not produce scholarly reports that draw attention to the profit-gouging by input suppliers and commodity traders?

Figure 9: Opinions about expanding Ontario's *Nutrient Management Act*

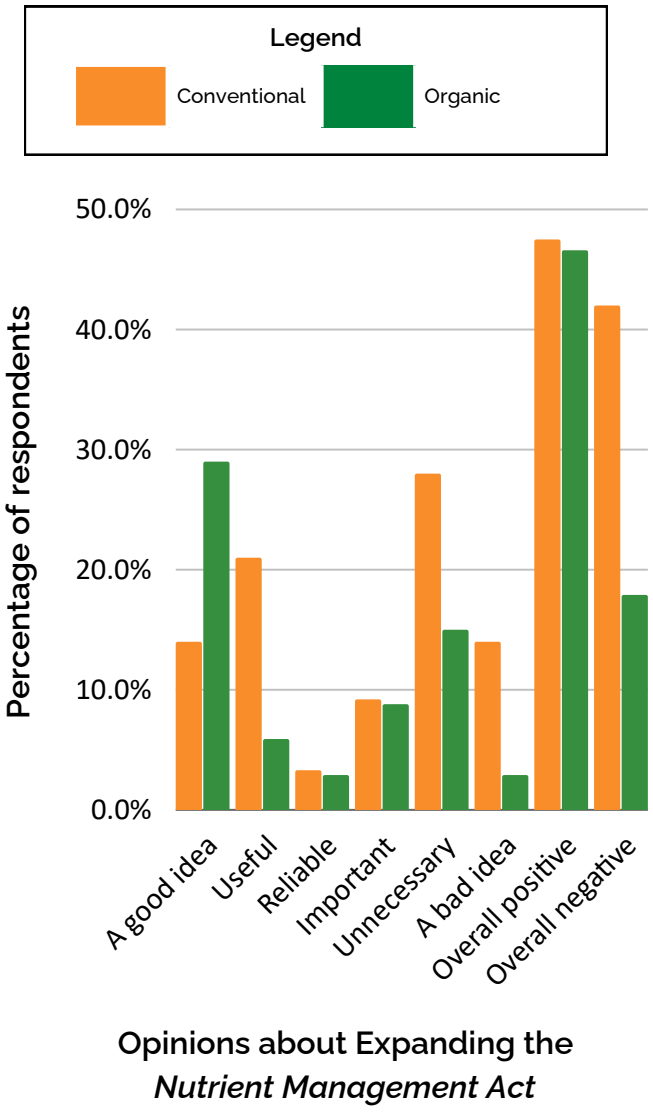


Figure 9. The percentage of conventional (n = 152) and organic field crop (n = 34) growers that voiced their opinion on a theoretical expansion of Ontario's *Nutrient Management Act* to include conventional field crop farmers.

In this survey, respondents opposed to crop nutrient management regulation expressed concerns that included the onerous paperwork and red tape, "we can't afford the paperwork costs," to a belief that a one-size-fits-all model would not work, "Ontario farmland is too diverse," to the ineffectiveness of the current livestock regulations, "they haven't fixed the manure issues even after mandating the management plans," to a general dislike of any "government regulations or interference." Others were more circumspect, "tough to say [it would work] without knowing more details," to "I'd rather it not be government mandated, but it could be useful and beneficial to the environment." But for the over 47% in favour of the idea, regulatory standards were heralded as one of a number of tools that could bring systemic change. "If we're [farmers] screwing up, we should be held accountable," said one, and another concluded that "many farmers are resistant to change." Another acknowledged such resistance, but recognized that "considering how much money farmers have tied up in land and equipment makes it harder for them to accept a potential risk to yields."

> ***Lack of penalties and regulation for farmers whose over application of fertilizer and lack of run-off controls are endangering the local water supply, local and distant ecosystems (especially aquatic) and contributing to climate change. This cannot simply be solved through incentives and education, we need to regulate!***
>
> **– Farmer Survey Respondent**

While several provinces, including Ontario, introduced regulations in the early 2000s to manage manure use, storage, and application (see the Livestock Farm section above), most jurisdictions have shied away from anything other than voluntary approaches to the management of synthetic crop fertilizers (OECD, 2017). In 2019, British Columbia became the first province to introduce regulations under its *Environmental Management Act* relating to all forms of agricultural nutrient use. The evolution of B.C.'s "Code of Practice for Agricultural Environmental Management" (AEM code), which replaced the province's Agricultural Waste Control Regulation, offers important insights relevant to the Ontario context.

BC's AEM code requires over 17,000 farm operations where manure OR synthetic fertilizers are applied to two hectares or more to conduct triennial post-harvest soil tests for nitrate and phosphorus in each field. Farmers are mandated to maintain records about nutrients applied, crop yields, and date, rate, type, and location of all applications. Where autumn soil tests record high nitrate results of over 100 kg N/ha in a "high risk area" (i.e. where the farm is located near a "vulnerable aquifer recharge area") or otherwise register 150 kg N/ha or more, farms are required to have a nutrient management plan (NMP) and to complete annual nitrate tests until nitrate levels fall below maximum thresholds. By 2025-2026, specific phosphorus-affected areas will need an NMP and annual phosphorus tests if they register with more than 200 ppm P (reduced to 100 ppm P in 2027) (BCMECCS, nd). The goal of the NMPs is to minimize the risk of nitrogen and phosphorus loss. The plan must be prepared by a qualified professional who has completed a course in nutrient management planning (British Columbia, 2019).

Under B.C.'s Beneficial Management Practices program, farmers are eligible for cost-share funding for some AEM code-related costs, including the development of NMPs. However, farmers must pay the full costs for all soil tests.

Farmers were leery about the AEM code at first, but John Andrews, a Nutrient Management Specialist with the BC Ministry of Agriculture and Food (BCMAF), shared that there was less opposition than expected due to "several persistent environmental issues that needed to be addressed." The code has been rolled out slowly with the aim to promote risk-based compliance through education and outreach before escalating to fines and enforcement.

The AEM code "has been positive overall for the sector," explains Paul Pryce, the Director of Policy at the BC Agriculture Council (BCAC), as it has "helped guard the sector against spurious criticism" and "contributes to a generally positive perception of the sector among the public and has allowed us to prevent situations in which policies or regulations are developed without us in response to some crisis." Pryce cited two recent instances where BC farmers might have been or were accused of causing algal blooms and poor water quality, but the AEM code proved they were not the cause and, instead of authorities creating arbitrary regulations against local farmers, they were able to ascertain the more likely source(s) of the water pollution.

The code took over two years to develop with "in-depth consultation carried out with industry groups," shared Anne Molony, the Environmental Management Officer with the BC Ministry of Environment and Climate Change Strategy. The AEM code was designed "'with' industry rather than 'to' industry," agreed Pryce.

Outreach continues as the code gets phased in. It may be too soon to adjudicate the code's overall effectiveness, but Josh Andrews, BCMAF, said there "does appear to be an improvement in understanding of vulnerable areas and management practices to limit environmental contamination."

Pryce and the B.C. government officials who spoke with us, shared three ideas that they believed would strengthen B.C.'s agricultural nutrient management and ought to be considered should other jurisdictions explore enacting a similar policy.

1. **Fully-funded public extension services for farmers.** Like Ontario, B.C.'s extension services are under-funded or non-existent and there is a shortage of professional agrologists. Many farmers who want Environmental Farm Plans have to wait far too long to get one. In other words, regulations are only effective if the resources and expertise are funded to support adherence.
2. **Regulation needs to be coupled with voluntary measures backed by incentives.** BC farmers abide by the AEM code to avoid fines and penalties. There are some efforts by the government to encourage voluntary improvements, but without incentives, farmers are not encouraged to go beyond the code.
3. **The Need for Farmer Education and Awareness**. Many B.C. farmers remain unaware of the AEM code and/or do not think it applies to them, indicating the need for ongoing outreach.

The industry's support for B.C.'s AEM code, alongside the government's inclusive and participatory process, has helped erode the idea that all farmers are resistant to regulation. In fact, in B.C., regulation is improving soil and water quality AND is encouraging the public to recognize the environmental stewardship of the province's agriculturalists. Time will tell if it also helps B.C. farmers push back against the fertilizer companies and their ever-more credo. If agricultural nutrient regulations work for British Columbia, why not Ontario?

Conclusion

> **It is clear that the targeted 40% reduction in nutrient loadings to the western Lake Erie basin will not be achieved without making significant progress reducing loadings from nonpoint agricultural sources (LimnoTech, 2022).**
>
> — Report prepared for the *International Joint Commission by the Great Lakes Science Advisory Board*

In spite of billions of dollars of investment in voluntary conservation and nutrient management programs in Canada and the U.S., agricultural nutrient runoff continues to pollute the Lake Erie basin with toxic algal blooms. Similarly, in recent years, more government funds have been devoted to supporting farmer-led solutions to on-farm greenhouse gas emissions (including emissions directly related to the use of synthetic nutrients and manure). These climate change programs are also entirely voluntary in nature and, while we have little data yet on their overall effect, participation rates, including those shared by survey respondents, remain troublingly low.

Many farmers care about soil and water health and also want to do their part in mitigating climate change. These farmers have voluntarily adopted a myriad of best agricultural conservation practices. However, this survey

supports other research that has determined that participation rates in voluntary programs rarely exceed 50%. Encouraging and supporting farmers who make voluntary ecological improvements, frequently at their own considerable expense, is important, but so too is finding ways to increase adoption among those who don't or won't.

A multi-pronged approach is required to adequately address and mitigate the agricultural sector's role in the eutrophication of Lake Erie and elsewhere and to realize the full potential of farmers' commitments to maintaining and improving water and soil health. We should not be quick to dismiss any of the options available as current fertilizer practices are leading to irreversible ecological damage, from toxic algal blooms to climate change acceleration. As one group of scholars put it, we need to think carefully about the "carrots dangled and sticks wielded" to "support a transition to sustainable agriculture," otherwise "global market forces" will "strengthen the current trend of large, highly industrialized farming, which is unsustainable" (Chalifour and McLeod-Kilmurray, 2016).

In particular, we need to: reintroduce public extension services to support soil testing and farmer education on all aspects of agricultural conservation practices; create a federal decentralized Canadian Farm Resilience Agency (CFRA) to help coordinate a sustainable transition to best conservation practices across the country; increase the quality and quantity of effective and targeted grants, subsidies, and cost-share programs for the voluntary adoption of best practices; revisit current agricultural tax incentives to make them conditional to on-farm ecological improvements; and offer revisions (with farmer input) to the *Nutrient Management Act* (2002) to include regulations around the use of synthetic fertilizers, alongside deploying more monitoring resources to ensure adequate risk-based compliance with the Act.

To actually address the agricultural sector's impact on Lake Erie eutrophication and climate change means that all of these proposed measures should keep as a guiding principle the need to challenge the business-as-usual goal of endless growth. As Darrin Qualman argues, "we should not expect efficiencies alone to provide significant or durable reductions" so long as efficiency is linked to maximizing yield. Isaac and de Loë (2020) make a similar argument when they point out that, while some corporate agricultural actors drop catchy green phrases like "deep ecology, expansion of wetlands, whole farm system transitions, and ecological farming," this posturing is "peripheral" to a larger push to adopt "the 'right mix' of voluntary, incentive-based and regulatory instruments for improved 'efficiency.'" They argue that actually resolving Lake Erie eutrophication will require dismantling the liberal capitalist pitch that we can have our cake (environmental protection) and eat it too (continual higher yields and economic growth). As other scholars frame it, we need "sustainability to be the driver, rather than simply another means of achieving economic growth" (Chalifour and McLeod-Kilmurray, 2016).

It is time to "practice intelligent restraint" (Qualman & NFU, 2022). Many farmers know and even practice the agricultural conservation practices that would support climate change solutions and the ecological integrity of soil and groundwater, but so long as these measures are implemented with a primary goal of yield increases, the environment will inevitably suffer.

The farmers who participated in this study help to point the way forward. A proactive and accountable farming community has the power to shift the dominant narratives away from denial or inaction by identifying and forwarding concrete farmer-led solutions to reduce and improve nutrient use. Doing so won't be easy, and there will be plenty of resistance from powerful conglomerates who will persist in their demand for a deregulated industry driven by yield maximization. But, the health of our land, water, and air, and the long-term viability of farming and the feeding of our population, requires that we confront the business-as-usual model of corporate agriculture. We have no time to lose.

Taken together, the following policy recommendations are considered crucial to advancing best agricultural conservation practices.

Recommendations

- **Reintroduce comprehensive Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) extension services for nutrient guidance:** We need government policy that supports the reintroduction of public extension services with trained agrologists capable of assisting farmers in calculating the most efficient and sustainable nutrient applications for their fields (including independent, i.e. non-corporate, advice on the right time, rate, source, and placement). **These extension services should also provide free annual soil testing for all farm operations.** This study found that less than 15% of conventional crop farmers regularly rely on OMAFRA's current nutrient management guidelines and the vast majority take commercial fertilizer suppliers' advice at face value, in spite of the evident conflict of interest.

- **Create a Canadian Farm Resilience Agency (CFRA)** to coordinate a rapid, science-guided, and least cost transition to financially secure, emission-minimizing farms and food systems. To reduce agricultural greenhouse gas (GHG) emissions and nutrient use across the country, we echo the call of the National Farmers Union and Farmers for Climate Solutions for the need for extensive, long-term support for farmers in: understanding and quantifying emissions; using fertilizer with maximum efficiency and effectiveness; optimizing and reducing use of other inputs; optimizing livestock systems; managing water and improving soils; and accessing agronomic advice independent of agribusiness corporations. The CFRA would help coordinate planning and delivery of agri-environmental and climate related programs across all provinces and territories (NFU, 2022; FCS, 2022).

- **Provide public education campaigns, including free and accessible training on "least cost crop production," or farming for maximum profit versus maximum yield:** Our survey data revealed that crop farmers spend, on average, one-fifth of their input costs on fertilizer and many shared concerns about the expense. This suggests that both the environment and farmers would benefit from education campaigns on practices/methods that reduce the total amounts of fertilizers required to grow their crops. These campaigns should also provide free and accessible training on the most up-to-date agricultural conservation practices. Many farmers were interested in exploring the possibilities of "least cost crop production" and farming for maximum profit rather than for maximum yield. Therefore, OMAFRA (and the proposed CFRA), alongside farm organizations, should offer workshops

and/or specific guidelines to help farmers get off the yield maximization treadmill wherein they realize diminishing returns via the overapplication of synthetic fertilizers.

- **Increase quality and quantity of public and private grants, subsidies, and cost-share programs:** Financial supports, like those currently offered under the Ontario Agricultural Sustainability Initiative, are required to support farmers who make voluntary improvements by adopting best agricultural conservation practices. These grants and subsidies need to be easy to apply for, equitably administered, and long enough in duration to measure the efficacy of any intervention, including for projects that require repeated, continuous improvements. These funds should target specific practices that have typically been too costly for farmers to voluntarily adopt, including those that may involve removing land from agricultural production (wetland and woodlot expansions, hedgerows, riparian buffer zones, etc.) to ones with higher upfront expenses (controlled tile drainage systems, specialized machinery, etc.)

- **Explore how participation in agricultural tax and federal program incentives could be made cross-compliant with the adoption and maintenance of on-farm agricultural conservation practices:** Such cross-compliant policy measures could include incremental revamping of Agriculture and Agri-Food Canada (AAFC) Business Risk Management programs, in particular AgriInvest, to incentivize farms that enact proven ecological improvements on their agricultural operations. Adding cross-compliance to current agricultural policy to achieve environmental goals could have the added benefit of helping to justify continued income support. **At the provincial/municipal level, we recommend exploring the possibility of making and sustaining ecological improvements a condition for farmers to receive either the full 25% agricultural property tax rate or introduce a further reduced conservation tax rate of less than 25% for those who adopt specific agricultural conservation practices.**

- **Revise the *Nutrient Management Act* (2002) to include synthetic fertilizer regulations and strengthen compliance measures:** Almost half of the farmers surveyed understood the need to augment voluntaristic approaches with specific regulations. We need to bring together farmers, scientists, and policy makers to design regulations that can serve as industry-wide standards in the use of synthetic fertilizers. In particular these regulations need to **make regular soil testing on all field crop farms a requirement** as it is impossible to adhere to sustainable 4R Nutrient Stewardship without it. These regulations might also include mandating the most effective agricultural conservation methods, such as riparian buffer zones, etc. B.C.'s Code of Practice for Agricultural Environmental Management (AEM Code) offers a useful template to begin these conversations. **These new and revised regulations, along with the ones already covered in the Act to regulate greenhouses and manure storage and application, need adequate compliance, monitoring, and enforcement both to be effective and to gain the public's trust.**

Definitions

Agricultural Conservation Practices: For the purposes of this report, agricultural conservation practices refer to all forms of fertilizer and manure application techniques, as well as soil and water control methods available to farmers that can help prevent water eutrophication and nutrient overloading.

Concentrated Animal Feeding Operation (CAFO): According to the United States Department of Agriculture, CAFOs are any operation with over 700 dairy cattle, 1000 meat cows, 2,500-10,000 pigs (depending on weight), 10,000 sheep, 55,000 turkeys 125,000 chickens, or 82,000 egg laying hens who are confined for over 45 days a year. CAFOs have proliferated in the United States. In Ontario, the *Nutrient Management Act* (see below) has a series of regulations that, among others, requires livestock farms over a certain number to have an adequate land base and management plan to ensure safe containment and spreading of animal waste.

Eutrophication: The overabundance of nutrients in a water body that causes a proliferation of primary producers resulting in periods of oxygen depletion from decomposing organic algal material. Eutrophication is frequently the result of nutrient loading from agricultural runoff.

4R Nutrient Stewardship: First introduced by industry, 4R nutrient stewardship is a voluntary approach that encourages the right formulation, rate, time, and source of nutrient application. Typically, the idea of what is "right" is based on a combination of efficiency and maximum yields, and not necessarily on what is "right" for the local ecosystem. For the purposes of this study, 4R nutrient stewardship is understood as what is sustainably and ecologically "right" by encouraging farmers to use the right formulation of nutrients at the *right* time (spring instead of fall/split applications to address nutrient deficits during growing period), *right* placement (subsurface banding over surface spreading), *right* source (maximize use of enhanced efficiency fertilizers which employ coatings and/or nitrification and/or urease inhibitors), and *right* rate (which includes regular soil testing to calculate nutrient balances and setting rates based on average, not maximum yields).

Grid sampling: Grid sampling helps to avoid test errors, by ensuring a more representative soil sample by collecting multiple sample(s) around plotted point(s) within a grid.

Harmful Algal Bloom (HABs): When algae and cyanobacteria grow excessively in a water body as a result of eutrophication and reduce oxygen levels and produce toxins that can kill other freshwater organisms. HABs can appear naturally but are frequently the result of human activity.

Least Cost Crop Production: Coined by one of our agricultural advisors, least cost crop production refers to the adoption of any production practices that serve to reduce synthetic nutrient inputs without reducing overall farm profit. This can include regular soil testing and the use of the 4Rs with the aim of maximizing profit over maximizing yield, and/or engaging in a variety of agricultural conservation practices that improve soil health and that help minimize synthetic fertilizers or manure applications.

Mixed-Commodity Farm: Any farm that produced at least two of the three main "farm types" from our study: field crops, livestock, and specialty.

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA): OMAFRA, an Ontario government ministry, oversees investments, markets, and regulations related to food, agriculture and rural sectors in the province.

Nutrient Units: Under Ontario's *Nutrient Management Act* (2002), all livestock are compared based on the average nutrient values of their manure, with one nutrient unit being based on the "value of the lower of 43 kilograms of nitrogen or 55 kilograms of phosphate."

Nutrient Management Strategy: Under Ontario's *Nutrient Management Act* (2002) all livestock operations with more than 5 nutrient units that are applying for a building permit are required to have an approved Nutrient Management Strategy (NMS) that requires farmers to calculate the amount of manure generated, provide proof of adequate storage capacity, present a management plan for all runoff as well as a sketch showing that any new facilities are within defined distances from all wells and water features.

Nutrient Management Plan: Under Ontario's *Nutrient Management Act* (2002) all livestock operations with more than 300 nutrient units (or that are within 100 m of a municipal well) are required to have an approved Nutrient Management Plan (NMP). In addition to the requirements of an NMS, farms requiring an NMP need to provide information on manure application in the fields, crop rotation, tillage method, project yields and outline any other management approaches used to "optimize the utilization of nutrients by the crops while safeguarding the environment."

Sustainable Agriculture: There is a slipperiness to the defining and use of the term "sustainable." No universal or official Canadian government definition exists. For the purpose of this report, we employ the term as it understood in U.S. legislation, as an "integrated system of plant and animal production practices" that "satisfy human food and fibre needs; enhance environmental quality and the natural resource base upon which the agriculture economy depends; make the most efficient use of non-renewable resources; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole." Specific sustainable agricultural practices include, among others, any actions that aim "to reduce agriculture's negative environmental impacts by reducing the use of pesticides, herbicides and /or fertilizers, limiting soil erosion and water runoff, and improving soil quality" (Chalifour and McLeod-Kilmurray, 2016).

End Notes

1. Unless otherwise indicated, the numbers that follow are from the full data set.

2. One livestock-only farm, one field crop-only farm, one specialty farm and four mixed commodity farms reported using both conventional and organic methods.

3. Interestingly, the CAPI report found that high farm incomes may be a limiting factor in sustainable practice as the number of farmers who self-identified as “sustainable improvers” dropped to 50% if they declared earnings over $5 million (McCann & Lika, 2023).

4. For the regulation of greenhouse nutrient use, see O.Reg. 300/14: Greenhouse Nutrient Feedwater, *Nutrient Management Act*, 2002, S.O. 2002, c.4, https://www.ontario.ca/laws/regulation/140300.

5. All Ontario farms also fall under Ontario’s *Clean Water Act* (2006) which requires farmers, whose activities are classified as significant threats to drinking water, put in place a legally-binding risk management plan to mitigate water contamination hazards.

6. OMAFRA’s recommended phosphate rates are based on soil tests of total sodium bicarbonate phosphorus (ppm); the maximum recommended rate is 110 kg/ha (OMAFRA 2017).

7. See, for example, Poon (2009) and Beechey (2012).

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