Chapter 4

Algae Everywhere

Contents

Lake algae: bad and getting worse.

Abstract

Algal blooms are becoming more frequent and wide-spread, and are imposing serious costs on communities. The problem affects not only Lake Erie, but also parts of Lake Huron and Lake Ontario and smaller inland lakes, especially on the Canadian Shield.

Controlling phosphorus – a critical ingredient in the development of algal blooms – was the key to cleaning up Lake Erie in the 1970s, and there is agreement that we now need more phosphorus controls. But there remains debate on exactly how and where to apply further controls. Run-off from rural, agricultural, and urban lands has become the dominant contributor to phosphorus loadings.

The Government of Ontario's preference so far for addressing phosphorus in run-off has been through voluntary and unevaluated programs, with questionable effectiveness. The government must apply new financial, regulatory and land use planning tools. For example, phosphorus trading approaches should be used more broadly, and incentives should support agricultural practices that can show quantified, validated reductions in phosphorus loadings. Bans should be applied where they can be effective, such as to the spreading of phosphorus-containing materials on frozen or saturated ground. The government must also adopt land use policy reforms to reverse the continuing loss of wetlands in southern Ontario. Previously overlooked phosphorus sources such as agricultural tile drains, construction sites and golf courses also need closer scrutiny.

4.0 Introduction

4.0.1 The Growth of Algal Blooms

Thick, soupy scums of algae – “algal blooms” – are becoming much more frequent in Ontario’s lakes (see Figure 1). In mid-July 2011, a toxic green blob began to spread across Lake Erie’s western basin. By mid-October that year, it had become the largest harmful algal bloom in Lake Erie’s recorded history, covering an estimated 5000 km^2. In 2014, the City of Toledo, Ohio declared a state of emergency when its water supply became contaminated with toxins from an algal bloom in Lake Erie, leaving almost half a million people without access to safe drinking water for days. The very next year, yet another algal bloom developed in Lake Erie and it was described as the most severe in this century.[1] If these trends continue, algal booms could cost tourism, real estate (through decreasing property values) and other sectors of the economy in the Canadian Lake Erie basin more than $270 million, according to a study prepared for the federal government.[2]

Not all algal blooms are alike. Water quality managers distinguish between “harmful” algae and “nuisance” algae. Species of blue-green algae or “cyanobacteria” are called harmful because they can produce potent toxins that can threaten drinking water sources, fish, and the overall health of a lake – sometimes in headline-grabbing fashion (as in the case of Lake Erie). Nuisance algae are species that do not produce toxins, but still foul shorelines and recreational areas, clog water intakes and ruin fish habitat.[3] Some other types of algal blooms (such as some types of diatoms) may not have any detrimental effects.

WHILE LAKE ERIE HAS A PROBLEM WITH HARMFUL BLUE-GREEN ALGAE, MANY OTHER WATERBODIES IN ONTARIO ALSO HAVE ALGAL BLOOMS OF VARIOUS KINDS.

While Lake Erie has a problem with harmful blue-green algae, many other waterbodies in Ontario also have algal blooms of various kinds. Near-shore stretches of Lake Huron and Lake Ontario are plagued by algae, mostly the nuisance variety.[4] Some parts of Lake Ontario, such as the Bay of Quinte, are showing a trend for more harmful algal blooms, according to a 2017 binational government overview.[5] There has also been a significant increase in the number of reports of algal blooms on smaller inland lakes, especially on the Canadian Shield, since the mid-1990s, according to data from the Ministry of Environment and Climate Change (MOECC).[6] Even Algonquin Provincial Park has problems with algae (see box, *An Algae Puzzle in Algonquin*). The season for algal blooms also seems to be extending. Blooms are now being seen later into the fall – even as late as November.

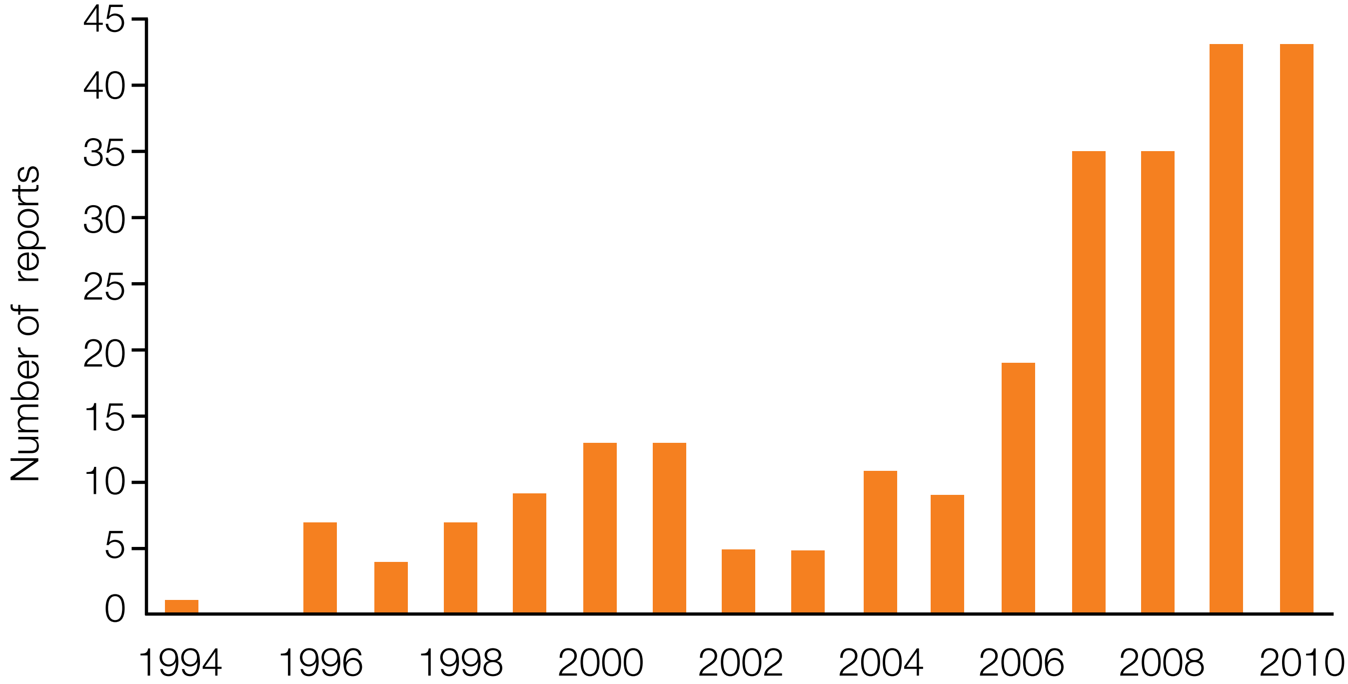

Figure 1. Number of confirmed algal bloom reports in Ontario, by year (1994-2010).[7]

Source: Adapted from the MOECC, Algae Blooms in Ontario's Lakes: Analyzing the Trends (2011).

An Algae Puzzle in Algonquin

Although scientists have come a long way towards understanding algal blooms since the 1970s, there is still much to be learned. For example, the discovery of algal blooms in three small lakes in Algonquin Park since 2015 presents a research puzzle for Ontario Parks. Dickson Lake, Lake Lavieille, and Ryan Lake are considered fairly pristine and have no cottages, though logging, quarrying and roads do occur in the area, yet all have had algal blooms. What's more, the lakes are not connected to each other, and the algae species observed in each are quite different – different types of blue-green algae species in Dickson and Ryan Lakes, and a golden algae in Lake Lavieille. There were no previous reports of algal blooms in the park before these, and lake sediment cores suggest no previous occurrences stretching back to 1756. Ontario Parks has closed overnight camping for canoers on these lakes, and advises visitors not to drink lake water even if treated or boiled. So far, monitoring suggests that local fish species and bald eagles are holding their own, but marked declines in dissolved oxygen have been observed as the algae decompose and deplete oxygen in the lake water. As of August 2017, the algal blooms persist.

4.0.2 Controlling Phosphorus to Control Algal Blooms

Phosphorus is a critical nutrient for plants, including phytoplankton – the base of the aquatic food chain. Phosphorus is also, however, a key ingredient in the development of algal blooms. As such, efforts to address algae need to focus on phosphorus.

Phosphorus controls proved very effective in the 1970s when Lake Erie last needed binational emergency help for severe nutrient pollution and algae problems. It made sense and was relatively easy to regulate what were then the biggest sources of phosphorus: wastewater treatment plants. Governments on both sides of the border passed laws requiring wastewater treatment plants to improve their phosphorus controls. Ontario and some American states also mandated low-phosphate detergents around the same time. These actions succeeded in dramatically reducing total phosphorus loadings to the Great Lakes between 1972 and the late 1980s.

THERE IS NO DEBATE: EVEN MORE PHOSPHORUS CONTROLS ARE NEEDED NOW.

Forty years later, there is no debate: even more phosphorus controls are needed now. In Lake Erie and elsewhere, the science is clear that our algal problems call for controls on phosphorus, since it is a key limiting plant nutrient in our lake systems.[8] But there is still debate on exactly how and where to apply these controls.[9]

Lake Erie's worsening troubles with algae have spurred new high-level binational commitments. In 2015, Ontario's Premier signed an agreement with the governors of Michigan and Ohio, collectively committing to an ambitious goal of reducing the total load of phosphorus entering Lake Erie's western basin by 40% by 2025.

Algal bloom at the western end of Lake Erie.

Source: NASA.

The agreement also sets an interim goal of a 20% phosphorus reduction by 2020 (from a 2008 base year). Sources on the American side contribute over 80% of the total phosphorus load to Lake Erie. Nevertheless, the signatories affirm that collaboration and proportional contributions from all areas of the Lake Erie basin will be vital. Intense discussions among government agencies and stakeholders are now underway.

THE TYPES OF ACTIVITIES RESPONSIBLE FOR THE LARGEST PHOSPHORUS LOADS IN THE GREAT LAKES REGION HAVE CHANGED.

4.1 Phosphorus and Algae Problems Have Changed

The nutrient challenges facing our lakes have evolved in important ways since the 1970s. The lakes affected in the 1970s are again having problems with algae, but the aquatic ecosystems themselves have been altered by new pressures, and now respond differently to phosphorus in its various forms. In addition, the types of activities responsible for the largest phosphorus loads in the Great Lakes region have changed. All these changes will need to be reflected in new solutions, and how we prioritize and fund them.

4.1.1 Nutrient Imbalance Has Developed Between Off-Shore and Near-Shore

A nutrient imbalance has developed between near-shore and off-shore regions for most of the Great Lakes.[10] In most of the Great Lakes except Lake Erie, phosphorus concentrations have been declining in off-shore regions, and may actually be getting too low to support productive food webs.[11] At the same time, near-shore regions often have an excess of nutrients, especially phosphorus.

Zebra and quagga mussels, which have invaded the Great Lakes since the late 1980s, are suspected to be part of the cause of this nutrient imbalance. Their dense colonies filter and trap phosphorus near shorelines, limiting its movement into open, off-shore waters and converting it to forms more easily used by plants such as algae.[12] Important near-shore aquatic habitats and recreational shorelines thus become clogged with dense growths of algae. This phenomenon, the so-called "near-shore shunt" of nutrients, was described in the ECO's 2010/2011 Annual Report, *Engaging Solutions* (Part 2.1).

Unlike the other Great Lakes, in Lake Erie phosphorus concentrations in off-shore waters exceed Ontario's interim water quality objective, and this trend has been worsening in the western basin. Loads of bio-available phosphorus, or "dissolved reactive phosphorus," have increased in Lake Erie because of increases in storm events and run-off, and changes in land use practices.[13]

4.1.2 Run-Off Has Taken Over as Largest Source of Phosphorus

The biggest sources of phosphorus have changed since the 1970s. Run-off from rural, agricultural and urban land has become the largest contribution to phosphorus loads. These are often called "non-point sources." In contrast, in the 1970s, the main sources of phosphorus were municipal wastewater treatment plants, called "point sources."[14]

The precise breakdown of the various non-point sources of phosphrous differs from watershed to

RUN-OFF FROM RURAL, AGRICULTURAL AND URBAN LAND HAS BECOME THE LARGEST CONTRIBUTION TO PHOSPHORUS LOADS.

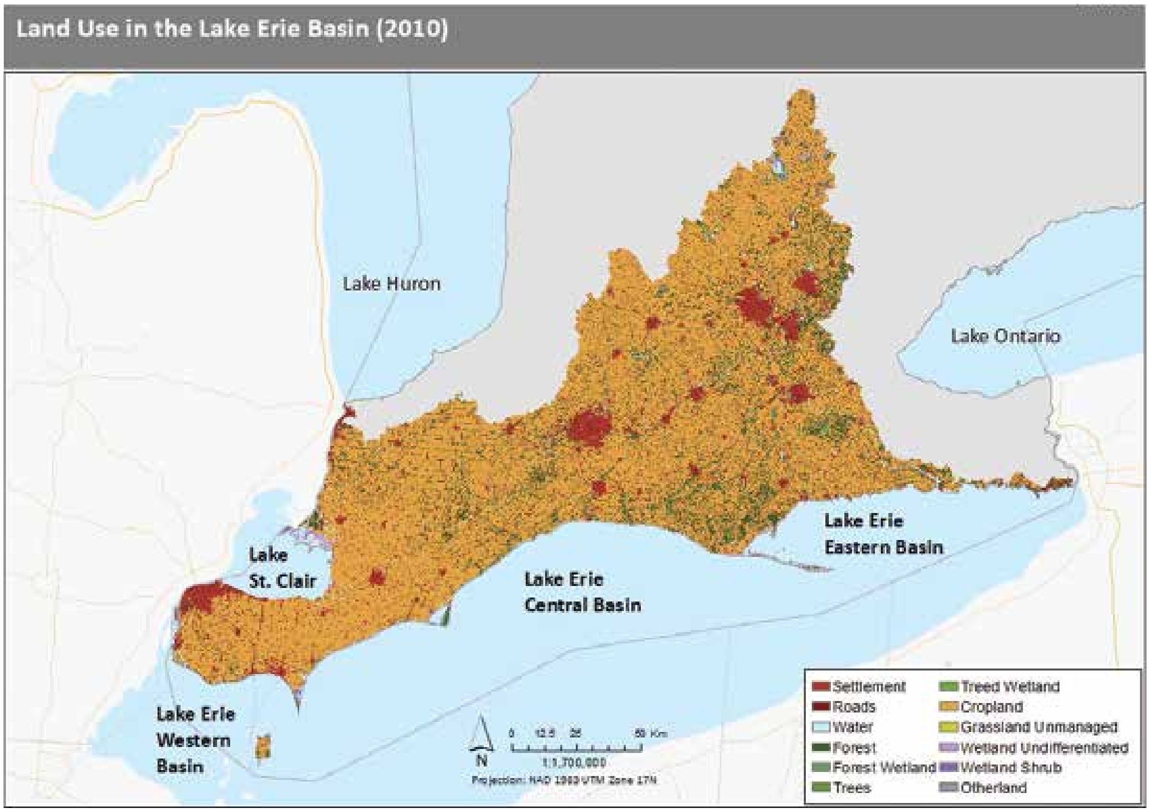

Figure 2. Land use in the Lake Erie basin (2010).

Source: Government of Canada, *Let's Talk Phosphorus Reduction in Lake Erie*.

watershed. For example, in Ontario's portion of the Lake Erie watershed, non-point sources contributed over 90% of the total phosphorus load during the 2003-2013 timespan. And since about three-quarters of Ontario's Lake Erie basin is agricultural (see Figure 2), the phosphorus contribution from farming has become an important part of the big picture.[15] Lake Erie now receives only minor phosphorus loads (estimated at 10-15% of total loads) from all urban sources (point and non-point).[16] In fact, while the lake's health has been deteriorating in recent years, phosphorus loads from point sources have continued to decrease.[17]

Lake Simcoe – which fortunately does not currently have a problem with toxic algal blooms, but which does have serious problems with phosphorus – receives the bulk of its phosphorus loads from non-point sources.[18] The main sources include surface run-off from agricultural lands (an estimated 29% of total loads, attributed to hay, pasture, croplands and polders) and urban run-off (an estimated 31% of total loads).[19] Agriculture contributes additional phosphorus through atmospheric deposition of airborne dust from fields.

4.1.3 More Soil Erosion From Farmlands

Farm practices have also changed since the 1970s. Soil erosion is a major mechanism for transporting

STRONG ECONOMIC PRESSURES HAVE SHIFTED ONTARIO'S FARMLANDS TOWARDS MORE INTENSIVE AGRICULTURE, WHICH INCREASES THE RISK OF SOIL EROSION.

phosphorus from land into waterways.[20] Strong economic pressures have shifted Ontario's farmlands towards more intensive agriculture, which increases the risk of soil erosion. Larger average field sizes, the loss of fencerows and windbreaks, and a dramatic shift from hay and pasture lands to more corn and soybean production have all been part of this broad trend.[21] Hay and pasture (or "forage") lands typically have year-round soil cover and lower erosion rates, but Ontario lost almost 290,000 hectares of forage lands in the five-year period from 2006 to 2011.[22] In contrast, soybean fields, once harvested, have less soil cover and less organic matter than other crops, leading to an increased risk of soil erosion. Within the Lake Erie basin, soybean production grew from 16% to 34% of total croplands in the 1981 to 2011 period.[23] Farm soil erosion rates in Ontario have gone up an average of 10-20% per decade in spring and summer seasons over recent decades.[24] The risk of erosion also increases on rented lands, where soil health tends to receive less attention.[25] Rented lands now make up about 35% of Ontario farmlands – a bigger chunk than in the 1970s.[26]

THE CONSEQUENCES: MORE RAIN FALLING ON BARE FARM FIELDS, MORE EROSION OF SOILS, WORSENING PHOSPHORUS RUN-OFF.

4.1.4 Climate Change

Finally, the climate is changing; since the 1970s, the Great Lakes have already experienced clear trends of rising temperatures, warmer waters and decreasing ice cover. We can also expect more rainfall, more frequent severe weather and less snow in winter months. The consequences: more rain falling on bare farm fields, more erosion of soils, worsening phosphorus run-off, and more algae in our lakes.[27]

UP TO 90% OF THE TOTAL PHOSPHORUS LOAD TO A RIVER CAN BE DELIVERED DURING STORM EVENTS.

4.2 The Search for Effective Approaches

When the sources of a pollutant change, management approaches must adapt. Research has convinced regulatory agencies to refocus on non-point sources of phosphorus, but tackling them is a challenge. Regulators must consider a multitude of land use practices and stakeholders, some far inland from the problems in the lakes. As well, nutrient loads often vary enormously with seasons, weather events and locations. For example, approximately 80% of phosphorus run-off from farmlands can occur in the non-growing season (November to April),[28] and up to 90% of the total phosphorus load to a river can be delivered during storm events.[29]

The Government of Ontario's preference so far for addressing phosphorus in run-off has been through voluntary and unevaluated programs, with questionable effectiveness. The ECO highlights several examples below that demonstrate the failure to evaluate the effectiveness of voluntary provincial programs for controlling non-point sources of phosphorous. Going forward, the government will need to evaluate the pros and cons of various management approaches. Traditional regulatory mechanisms, economic instruments and land use planning policy approaches are all on the table for discussion.

MOST MUNICIPALITIES HAVE NOT BEEN MONITORING OR MAINTAINING THEIR PONDS.

4.2.1 Stormwater Management

Run-off from rain or melted snow in urban areas, known as stormwater, can add a big burden of phosphorus to water bodies. Lawn fertilizers, soil, dust, litter and pet waste all add phosphorus to stormwater as it races across urban pavements and roofs.

Stormwater management ponds, which offer end-of-pipe treatment, allow suspended pollutants to settle, and send cleaner waters on to rivers and lakes. They are popular with municipalities, and thousands have been installed across Ontario since the late 1980s. When they work well, stormwater ponds can reduce total phosphorus loads by 50 – 80%.[30] But they don't always work well; ponds need to be dredged periodically in order to function and dredging is expensive. Municipalities typically underfund their stormwater management, as reported in the ECO's 2016 report, *Urban Stormwater Fees: How to Pay for What We Need*. Also, most municipalities have not been monitoring or maintaining their ponds, and the MOECC has so far declined to set any rules for their maintenance, an issue the ECO previously raised (see our 2010/2011 Annual Report, *Engaging Solutions*, Part 4.5). Without any monitoring, municipalities themselves are not sure if their ponds are effective for controlling water quality.[31]

Fortunately, some creative new stormwater approaches are being tried, with phosphorus control either a main driver or a co-benefit. These projects are being tried by provincial ministries, municipalities, conservation authorities and the private sector.

A key principle guiding much of the innovation in stormwater management is the need to plan at multiple geographic scales (e.g., from entire watershed to single residential lots). For example, the *Lake Simcoe Phosphorus Reduction Strategy* (2010) aims to manage phosphorus at a very large watershed scale. Lake Simcoe's program features an ambitious overall phosphorus load reduction target and, nested within that, reduction targets portioned out to all the contributing phosphorus sources.

A second guiding principle in stormwater management is the need to adopt and adapt nature's approaches to community design and development. Lot-scale features such as grassy swales, rain gardens, permeable pavements and green roofs can mimic ecosystem processes, including absorbing and filtering stormwater. Stormwater practitioners are increasingly adopting these Low Impact Development (LID) features, recognizing they can function as cost-effective "green infrastructure." LID features will also be championed by the MOECC's *Low Impact Development Stormwater Management Guidance Manual*, expected to be finalized by late 2017.

However, the ministry's forthcoming LID manual focuses mainly on controlling stormwater *volumes*, rather than stormwater *quality*. Indeed, volume controls seem to dominate most technical discussions about LID features so far. But successful volume control does not necessarily equal good phosphorus control. Some LID features are far better than others at improving water quality. Bioretention areas, for example, which use specialized soil media covered by vegetation, can be relatively effective in removing pollutants.[32] While some very helpful guides are now available, such as the "Grey to Green" series of LID guides issued by the Credit Valley Conservation Authority, it is clear that more evaluation and research is still needed on water quality controls for stormwater.

This suggests we should adopt a third principle to guide stormwater management, if we hope to reverse current trends of algal blooms: the need to monitor, quantify and report on how projects at every scale are affecting water quality, and specifically phosphorus levels. Of course good ideas need trial and error phases, and overnight results are not to be expected. But as phosphorus control programs roll out, they will need the rigour of clear targets, and strong, ongoing evaluation.

AS PHOSPHORUS CONTROL PROGRAMS ROLL OUT, THEY WILL NEED THE RIGOUR OF CLEAR TARGETS, AND STRONG, ONGOING EVALUATION.

4.2.2 Farming Best Management Practices

Ontario farmers have been encouraged to adopt environmental Best Management Practices (BMPs) through the voluntary Environmental Farm Plan Program (which operates across all Canadian provinces) since the 1990s. Through this program, farmers voluntarily prepare assessments to increase their knowledge of a wide range of on-farm environmental issues. The program also offers federal-provincial cost-sharing incentives to tackle issues like soil and water protection. However, there has been no measurement of how effective the Environmental Farm Plan Program has been at reducing, or even targeting, phosphorus run-off or other water quality concerns – a gap noted by the ECO in our 2010/2011 Annual Report, *Engaging Solutions*, Part 2.1.

The program's design includes no outcome-based monitoring or follow-up by provincial ministries, despite public funding of over $100 million in the 2005-2010 period alone.[33] Available metrics suggest program uptake in Ontario remains low. Only 38% of Ontario farmers had an Environmental Farm Plan, according to a 2012 survey by Statistics Canada;[34] and among participating Ontario farmers, less than 40% had fully implemented their plans. A separate 2010 survey found that, on average, participating farmers were implementing 65% of their plans and had invested $70,000 in agri-environmental activities.[35] By contrast, 72% of Quebec farmers had an Environmental Farm Plan, and almost 80% of those farmers reported having fully implemented their plans.

THERE HAS BEEN NO MEASUREMENT OF HOW EFFECTIVE THE ENVIRONMENTAL FARM PLAN PROGRAM HAS BEEN AT REDUCING, OR EVEN TARGETING, PHOSPHORUS RUN-OFF OR OTHER WATER QUALITY CONCERNS.

Ontario's modest participation rates and investment levels have not been enough to curb nutrient run-off at a landscape level. A 2012 MOECC study of 15 streams in agricultural watersheds in southwestern Ontario found nutrient loadings were either the same or appreciably higher than 30 years ago.[36] In 2017, the International Joint Commission (IJC) emphasized that voluntary agricultural programs are not sufficient to achieve target nutrient loadings for Lake Erie, in light of frequent harmful algal blooms in the last decade.[37]

4.2.3 Nutrient Management Rules for Farming

Manure produced by certain livestock farms is regulated by Ontario's *Nutrient Management Act, 2002*. The main

THERE IS NO AVAILABLE DATA TO SHOW WHETHER NUTRIENT LOADINGS FROM MANURE HAVE IN FACT CHANGED AS A RESULT OF THIS LAW.

environmental aim of this law is to reduce the risk of nutrients entering ground or surface water from both nutrient storage and land application of nutrients. To comply with this law, an estimated 4,600 farms must meet manure storage requirements. Of those farms, an estimated 1,150 large operations must also prepare and follow nutrient management plans.

Unfortunately, there is no available data to show whether nutrient loadings from manure have in fact changed as a result of this law. Both the ECO and Ontario's Auditor General have noted the lack of evalutation of the law's effectiveness and its limited coverage.[38] The Auditor General observed in 2014 that less than half of Ontario's livestock manures by volume were actually being managed under this regulatory structure, since many small and mid-sized farms are not captured. Moreover, for regulated farms, the Auditor General found a very low (3%) inspection rate for 2013/2014, and only minor ongoing follow-up for non-compliance. In response, the MOECC did strengthen some aspects of its inspection work. The IJC in 2014 similarly called for stronger regulatory mechanisms to reduce nutrient loadings from agriculture, since dissolved reactive phosphorus levels have been steadily increasing in many agricultural watersheds, despite decades of incentives and education programs.[39]

4.3 Provincial Leadership is Important

Reversing current trends for algal blooms – both their growing severity and widening geographic reach – will not be simple. The province will have to lead with creative collaboration and a more effective policy toolkit, because no single municipality or conservation authority has the clout or the resources to tackle the full range of phosphorus inputs to a regional watershed, let alone the entire Great Lakes basin. Only the province has the necessary breadth of mandate and legislative authority, through laws such as the *Ontario Water Resources Act*, the *Nutrient Management Act 2002*, the *Lake Simcoe Protection Act, 2008* and the *Great Lakes Protection Act, 2015*.

The province has stepped up by working with the federal government to release the draft *Canada-Ontario Action Plan for Lake Erie* in March 2017 (still in draft as of September 2017). The draft plan acknowledges that past actions are not enough, that new approaches are needed, and that both point and non-point sources (urban and agricultural) deserve scrutiny for new control options. The draft plan also places a welcome emphasis on research, monitoring and collaboration. Above all, the draft plan can be read as a tacit acknowledgement that our reliance so far on voluntary and unevaluated phosphorus control programs has not served Ontarians well. Financial, regulatory and land use policy tools must also be examined, tested and added to the phosphorus control tool kit.

OUR RELIANCE SO FAR ON VOLUNTARY AND UNEVALUATED PHOSPHORUS CONTROL PROGRAMS HAS NOT SERVED ONTARIANS WELL.

4.3.1 Financial Tools

Financial tools that put a price on phosphorus offer some potential means of controlling nutrient loads. Two examples – phosphorus trading and financial incentives – are discussed below.

POLLUTANT TRADING CAN BE A COST-EFFECTIVE WAY TO REDUCE POLLUTION LOADS.

Phosphorus Trading

Pollutant trading can be a cost-effective way to reduce pollution loads wherever pollution sources have widely differing control costs. For example, it can be very costly to achieve small improvements in phosphorus controls at a municipal sewage treatment plant, while run-off from farms or urban areas nearby could be far cheaper to control, per kilogram of phosphorus.[40] So to achieve the same overall phosphorus load target, it could be cheaper for the sewage treatment plant to pay local farmers to reduce their phosphorus run-off.

Phosphorus trading (or "water quality trading") has already been working since 1998, under the South Nation Total Phosphorus Management Program in eastern Ontario. The South Nation program is considered one of the most successful in North America. Its trades, which require a 4 to 1 trading ratio (i.e., the trade must redcue four times more phosphorus than would have been discharged without the trade), have so far financed projects for feedlot run-off controls, manure storage facilities, milk house wastewater treatment, as well as cattle fencing and cover cropping. Trading approaches such as these should be used more broadly. Encouragingly, the province proclaimed legal amendments in July 2017 that confirm its power to establish and govern water quality trading in Ontario.[41] Under a different framework, a phosphorus offsetting pilot project is being finalized for implementation in the Lake Simcoe watershed in late 2017. The program will require developers to purchase offset credits for any phosphorus discharges from new or redevelopment projects in the watershed.

Targeted Funding for On-Farm Phosphorus Controls

Strong economic pressures have shifted farm operations towards practices with greater risks of soil erosion. But rewarding agricultural practices that demonstrably reduce phosphorus loads through smart economic incentives could push them in the opposite direction. The main challenges with this approach are verifying improvements, and putting the right price on those improvements.

So far, Ontario has taken only baby steps towards such an incentive model. Several small-scale programs jointly funded by the provincial and federal governments have been encouraging farm stewardship projects, often short-term. A modest $4 million per year, over four years, has been allocated for farm soil health projects

REWARDING AGRICULTURAL PRACTICES THAT DEMONSTRABLY REDUCE PHOSPHORUS LOADS COULD PUSH THEM IN THE OPPOSITE DIRECTION.

and environmental stewardship in the Lake Erie and Lake Huron basins.[42] Similarly, a cost-share program offered in the Lake Simcoe watershed from 2008-2012 funded 440 on-farm projects.[43] Demand for such programs often exceeds available funding.

For a more strategic approach, the province needs to tie financial incentives to explicit phosphorus loading reduction targets, with an emphasis on quantifying and validating reductions. Targets and metrics are critical for learning which practices are most effective under different field conditions. Rented farmlands would likely need specially tailored incentives, since tenant farmers do not recoup investments on long-term soil improvements and thus tend to place a lower priority on soil conservation. A markedly expanded program is also needed to reflect the scale of the phosphorus problem.

One attractive funding option for phosphorus management programming would be to redeploy the more than half a billion dollars in fossil fuel tax breaks the province issues every year, as recommended by the ECO's 2015/2016 Annual Energy Conservation Progress Report; the agricultural sector received $28 million to subsidize fossil fuel consumption in 2015 as part of this program.[44] Supporting soil health and other farm-based ecosystem services would be far more sustainable than subsidizing fossil fuels. The ECO recommended the province provide financial support for farmers adopting soil health best management practices in our 2016 report, *Putting Soil Health First*. There is some promise in the fact that Ontario committed in 2016 to "look at removing existing [subsidy] initiatives that support fossil fuel use."[45]

4.3.2 Regulatory Tools

When voluntary measures are not achieving the desired results, government should consider regulation. For example, regulations can be used to ban certain activities, as appropriate, to control phosphorus run-off, as described below.

SPREADING FARM MANURE ON FROZEN OR SATURATED GROUND GREATLY INCREASES THE RISKS OF THE MANURE RUNNING-OFF.

Ban the Spreading of Farm Manure and Fertilizer on Frozen or Saturated Ground

Spreading farm manure on frozen or saturated ground greatly increases the risks of the manure running-off and the phosphorus entering waterways. Ontario's *Nutrient Management Act, 2002* sets standards for winter spreading, at least for the estimated 1,150 farms requiring nutrient management plans under the law. But so far, the law applies to less than half of the total volume of farm manure produced in the province and only a quarter of Ontario's livestock operations.[46]

Ontario's golf courses and urban areas have no restrictions on phosphorus applications. In contrast, jurisdictions like Manitoba and Indiana have set much broader and stronger prohibitions on winter spreading. For almost a decade, Manitoba has restricted winter spreading of all types of fertilizers, including manures and sewage sludges, on farmlands and golf courses.

The International Joint Commission (IJC) recommended in 2014 that Ontario and other Great Lakes jurisdictions ban the winter spreading of manures, sewage sludges and phosphate fertilizers on farmlands in the Lake Erie basin.[47] Given that over 80% of agricultural phosphorus run-off can occur in winter,[48] the IJC's recommendation seems a minimum requirement. Rules prohibiting the winter spreading of any materials contributing to phosphorus run-off should apply across the province. As of February 2017, Ontario was "considering further restrictions" on the winter spreading of nutrients,[49] but has taken no action so far.

The Fertilizer Industry's Voluntary Phase-out of Phosphorus in Lawn Fertilizers for Canada

Phosphorus in lawn fertilizer has been restricted or banned in many U.S. Great Lakes states, including Illinois, Indiana, Michigan, Minnesota, New York and Wisconsin, which has proven effective at reducing phosphorus loads in waterbodies. One year after Ann Arbor, Michigan had introduced a lawn fertilizer by-law, total phosphorus had declined by an average of 28% in local rivers.[50] After a dozen years regulating phosphorus use on lawns, Minnesota was able to report good public support and significant drops in phosphorus application to lawns, even without enforcement.[51] In Canada, Manitoba and Sudbury have similarly restricted phosphorus in lawn fertilizers in recent years. "Phosphorus-free lawn" jurisdictions typically offer public education on successful phosphorus-free lawn care, and usually allow exemptions for some special situations such as newly established lawns.

PHOSPHORUS IN LAWN FERTILIZER HAS BEEN RESTRICTED OR BANNED IN MANY U.S. GREAT LAKES STATES.

In 2010, perhaps in response to this regulatory trend, members of Fertilizer Canada, an industry association, voluntarily eliminated phosphorus from most of their lawn products. An important next step is for the Ontario government to evaluate and monitor whether this voluntary measure is achieving results.

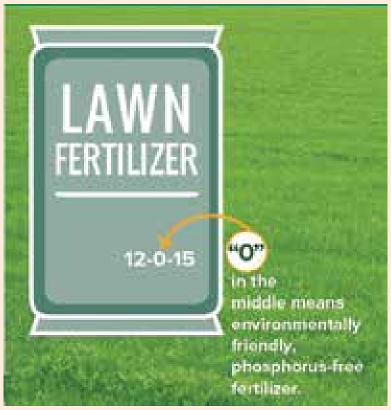

Figure 3. Educational tool to support phosphorus-free lawn fertilizer.

Source: New York State.

4.3.3 Land Use Policy Tools

Land use policy can be another effective tool for controlling phosphorus. For example, there is a need for policies that better support the role of wetlands in mitigating phosphorus loads.

Reverse the Net Loss of Wetlands

Wetlands store and filter run-off, and are also recognized for their important ecological roles in storing and processing phosphorus. Exactly how effective wetlands are at trapping phosphorus varies by site; one review of studies world-wide suggests wetlands can achieve phosphorus reductions of 50-90%.[52] When wetlands are disturbed, however, they can become net releasers of phosphorus.

ONE REVIEW SUGGESTS WETLANDS CAN ACHIEVE PHOSPHORUS REDUCTIONS OF 50-90%.

Southern Ontario has seen a drastic loss in wetlands, estimated at 70%, since European settlement. The net loss of wetlands continues today, driven by development pressures, though losses may have slowed over the last decade.[53] Reversing the net loss of wetlands should be a key provincial goal, not just because they protect water quality, but also because they provide critical habitat, and buffer watersheds in times of flood and drought.

Unfortunately, the province's new *Wetland Conservation Strategy for Ontario 2017-2030*, finalized in July 2017, accepts the continued shrinking of wetlands in southern Ontario for nearly another decade. The strategy also accepts that southern Ontario will see no net gains of wetland area until 2030. Here again, weak metrics hamper decision making; the strategy provides no data or even comparative estimates of how much wetland area is lost annually to pressures such as residential and commercial development, agricultural drainage or transportation infrastructure. The strategy does, however, recognize the need for an improved wetland inventory as a starting point.

PHOSPHORUS IMPACTS FROM ONTARIO'S GOLF COURSES ALSO DESERVE SCRUTINY.

4.3.4 Research is Also Needed

Research and innovation must remain high priorities in tackling Ontario's phosphorus and related algal bloom challenges. In contrast to the success stories of the 1970s and 1980s, a single "silver bullet" is unlikely to be found. The geographic spread of the issues and their ecological and societal complexities are simply too great. For example, since agricultural tile drains have been shown to play a role in increasing levels of bioavailable phosphorus in certain soils, farmers need verified best management approaches to minimize phosphorus run-off via tile drains.[54] The province's ongoing work on farm soil health and the promised provincial soil strategy will also need to address phosphorus issues.

In urban settings, some overlooked phosphorus sources also need much more research attention. Construction sites, for example, often add very large loads of sediment and phosphorus to waterways.[55] Erosion rates at construction sites can be 3 to 100 times greater than crop lands, according to a 2001 U.S. stormwater management handbook.[56] Phosphorus loads from construction sites may be similarly significant in rapidly urbanizing regions of southern Ontario.[57]

Phosphorus impacts from Ontario's golf courses also deserve scrutiny, since the province has well over 800 golf courses,[58] mostly clustered in southern Ontario. Studies by the U.S. Department of Agriculture and others show that run-off from golf courses contains high phosphorus loads – comparable to rates from agricultural lands.[59] The State of Virginia now requires all golf courses to complete nutrient management plans, including soil tests. No such requirements exist in Ontario. Under a voluntary program offered by the Audubon Society, golf courses can be certified if they commit to minimizing nutrient run-off and monitoring for nutrients like phosphorus. Only 5% of Ontario's golf courses have opted to be certified under this program.[60]

4.4 Conclusions: Phosphorus Controls Need Muscle and Metrics

Phosphorus run-off and algal blooms are serious problems in Ontario. Lake Erie and Lake Simcoe are particularly hard-hit by phosphorus problems, but the trend is also evident for stretches of Lake Ontario and Lake Huron, as well as many smaller northern inland lakes.

The province has shown leadership in tackling phosphorus loads in Lake Erie and Lake Simcoe, committing to targets and actions for phosphorus control. The three key ministries – the MOECC, the Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and the Ministry of Natural Resources and Forestry (MNRF) – are all actively engaged. The focus on non-point sources in these two regions and the strong collaboration with partner agencies are commendable. But the growing geographic extent and scale of algal blooms demand that the Ontario government apply a stronger and more widespread approach to protecting the health of our lakes.

WELL-DESIGNED PRICE SIGNALS CAN ALSO BECOME PART OF THE SOLUTION.

Financial tools will be vital to stem phosphorus loadings to Ontario's waterways, from both agricultural and urban non-point sources. Strong economic pressures towards intensive agriculture have been helping drive current phosphorus loadings, but well-designed price signals can also become part of the solution.

The ECO recommends that the MOECC and the OMAFRA link financial incentives to verified reductions in farm-based phosphorus run-off to water courses.

The ECO also repeats our 2016 recommendation that the province require municipalities to recover the full costs of stormwater management, including not only capital costs, but also costs of operations, maintenance and research and development. Properly managing stormwater can help reduce phosphorus loads that contribute to algal blooms.

Some types of phosphorus loadings need regulatory action.

The ECO recommends that the MOECC and the OMAFRA ban all spreading of phosphorus sources, such as manure, fertilizer and sewage sludge, on frozen or saturated ground.

Land use planning tools cannot be ignored, given the clear connections between land uses and phosphorus run-off. Southern Ontario's remaining wetlands can help trap and immobilize phosphorus, but only if they are protected from agricultural drainage and encroaching development.

The ECO recommends that the MNRF reverse the continuing loss of wetlands in southern Ontario.

Lastly, metrics and evaluations need to become a priority for the province. With a daunting variety of land uses implicated in phosphorus loadings, managers need trustworthy, loadings-based metrics to identify the top challenges and the most cost-effective solutions in any given setting.

The ECO recommends that the MOECC, the OMAFRA and the MNRF ensure that metrics-based and outcome-driven evaluations are built into all programs and strategies that the ministries lead, fund or partner on. Phosphorus control programs should, for example, require quantitative loadings targets, monitoring, quantitative evaluations and regular reporting as core elements.

METRICS AND EVALUATIONS NEED TO BECOME A PRIORITY.

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