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Building partnerships to scale up conservation: 4R Nutrient Stewardship Certification Program in the Lake Erie watershed

Carrie Vollmer-Sanders [a,*], Andrew Allman [b], Doug Busdeker [c], Lara Beal Moody [d], William G. Stanley [e]

[a] The Nature Conservancy, 620 East Ohio Street, Indianapolis, IN 46202, USA
[b] Ohio AgriBusiness Association, 5151 Reed Rd., Suite 126-C, Columbus, OH 43220, USA
[c] The Andersons, Inc. (Retired), PO Box 119, 1947 Briarfield Blvd, Maumee, OH 43537, USA
[d] The Fertilizer Institute, 425 Third Street, S.W., Suite 950, Washington, D.C. 20024, USA
[e] The Nature Conservancy, 6375 Riverside Drive, Dublin, OH 43017, USA

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ABSTRACT

Harmful algal blooms in the Western Lake Erie Basin (WLEB) can be considered a wicked problem—there are conflicting interpretations of the problem and science, stakeholders have different values and goals, and there is no definitive solution. This paper provides an overview and lessons learned of how one set of diverse stakeholders worked together to initiate a voluntary 4R Nutrient Stewardship Certification Program to address the wicked problem in the WLEB. 4R Nutrient Stewardship (Right rate, Right time, Right place, and Right source) provides the foundation for a science-based framework that achieves sustainable plant nutrition management while considering the environment, society, and economics. The 4R Certification Program ensures a third-party auditor objectively evaluates the nutrient service providers' implementation of the 41 criteria of the program that encompass education, recordkeeping, nutrient recommendations, and applications. While the environmental impact of 4R Certification Program adoption is being evaluated currently, implementing the 4Rs has been identified as a key step to improving water quality. In two years, the 4R Certification Program has influenced nearly 40% of WLEB's farmland through the 30 4R certified providers. While any single organization could have created a nutrient management program, it would not have been as robust, as practical, or as accepted as the one created by the broad group of stakeholders involved with the WLEB 4R Advisory Committee. The rigor, structure, governance, and credibility of the 4R Certification Program make it a top candidate to act in other regions with wicked problems related to nutrient management.

Introduction

Harmful algal blooms in the Western Lake Erie Basin (WLEB) can be considered a wicked problem. Wicked problems have no definitive solution and require practical approaches with many stakeholders to effectively address and improve the situation (Batie, 2008). Stakeholders facing wicked problems have conflicting interpretations of the science, the problem, and the goals. Accordingly, policy makers, public health professionals, and other stakeholders who grapple with these problems cannot expect to resolve them effectively by relying solely on expert-driven, scientific approaches to problem solving (Kreuter et al., 2004).

The severe, harmful algal blooms (HAB) found in the WLEB meet the definition of a wicked problem on all accounts. The algal bloom is connected to a multitude of sources: water treatment plants, combined sewer overflows, surface and subsurface farm field losses, increased rainfall intensities, economics of providing drinking water, aquatic invasive species, and vitality of the fishing, boating, and birding industries (Smith et al., 2015). Many solutions to the HAB problem have been suggested. They generally fall into a limited set of categories: urban or rural nutrient management, edge of field practices, additional funding or cost-share for conservation practices, legal or regulatory, habitat restoration, scientific research, or technological innovation (International Joint Commission, 2014; Ohio EPA, 2013). While any one of these may be appropriate at different times and places, it will undoubtedly require a combination of approaches across the entire watershed to meet the currently accepted goal of reducing the dissolved reactive phosphorus spring load by 40% (International Joint Commission, 2014; CGLSLGP, 2015). Regardless, agricultural nutrient management, specifically, managing nutrient inputs onto farm fields, remains a major component of addressing the system-wide nutrient issues (Keitzer et al., 2016-in this issue). Nonpoint sources, including agriculture, are estimated to be responsible for about 61% of the total

* Corresponding author. Tel.: +1 317 951 8818.
E-mail address: csanders@tnc.org (C. Vollmer-Sanders).

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phosphorus load entering Lake Erie each year; in the WLEB, nonpoint sources are estimated to contribute over 80% of the annual total phosphorus load in that basin (Ohio EPA, 2010).

In 2011, heavy spring rains flushed a large amount of phosphorus into WLEB. This was soon followed by warm temperatures, creating a mass of algae that extended nearly 2000 mi^2 (5100 km^2), three times larger than the next largest bloom previously recorded (International Joint Commission, 2014). The size, intensity, and public attention the HAB created brought the agricultural and conservation communities together to discuss solutions. When discussions began, there were limited regulatory and voluntary programs available, and typically each state and/or watershed had its own effort. Nutrient service providers, those entities that provide farmers with fertilizer recommendations and application services were not significantly involved in conservation promotion, programs, or practices. However, farmers rely on these advisers as a major source of information on nutrient management and application decisions (Stuart et al., 2014). The focus on supporting 4R nutrient stewardship (Right source of nutrients at the Right rate, the Right time, and in the Right place) was among the first efforts in the WLEB to engage nutrient service providers in practices that impact water quality.

The concept of 4R nutrient stewardship was developed by the International Plant Nutrition Institute, Fertilizer Canada, and The Fertilizer Institute (Bruulsema et al., 2009). It provides a framework to achieve cropping system goals, such as increased production, increased farmer profitability, enhanced environmental protection, and improved sustainability. 4R nutrient stewardship is the implementation of best management practices (BMPs) on a site-specific basis to optimize the efficiency of fertilizer use. Properly managed fertilizers can increase profitability and decrease nutrient losses that would potentially degrade natural resources. The 4R approach provides a science-based framework for plant nutrition and sustained crop production (Bruulsema et al., 2009).

The agricultural industry recognized improved nutrient management as one aspect of a more comprehensive approach to a wicked problem, and proactively created the WLEB 4R Nutrient Stewardship Advisory Committee (Advisory Committee) (OABA, 2016b). The Advisory Committee discussed the possibility of several programs that could help spread the 4R nutrient stewardship message. A program targeting farmers, similar to a certainty program like Maryland's Agricultural Certainty Program (Maryland Department of Agriculture, 2016) or the Michigan Agriculture Environmental Assurance Program (MAEAP) (Vollmer-Sanders et al., 2011) would mean tens of thousands of farmers would need to trust the program messenger and/or see enough value in the program to be part of the program. Nutrient service providers are the entities farmers trust when making nutrient management decisions. Farmers purchase their nutrients from agricultural retailers, hire crop advisers to receive nutrient recommendations, and often hire applicators to spread the nutrients. While farmers make the ultimate decisions when managing their land, nutrient service providers help them make decisions. The Advisory Committee determined that a program should be targeted toward the nutrient service providers and there were two options discussed: (1) a pledge program like the Keep it for the Crop 2025 program in Illinois (Illinois Fertilizer Chemical Association, 2016) where a nutrient service provider pledges to a follow a set of criteria or take specific actions, and (2) a certification program like Forest Stewardship Certification (Forest Stewardship Certification, 2016) where the forest manager or company goes through an audit to ensure they are meeting each criteria laid out in the program. After reviewing the options, the Advisory Committee developed and subsequently launched the 4R Nutrient Stewardship Certification Program (4R Program) in 2014. To ensure transparency and opportunities for input beyond the Advisory Committee, SCS Global Services was contracted to guide the development of the certification standard and audit guidelines and subsequently train independent, third-party auditors.

In this paper, we provide an overview and lessons learned of how one set of diverse stakeholders worked together to initiate a program to address the wicked problem in the WLEB. The goals of this paper are: (1) to review the development of the standard and the practices that are included, (2) to explain the governance of the 4R Program, and (3) to describe the impact and influence of the 4R Program. This paper does not include a scientific review of the effectiveness of the criteria required by the standard.

4R Nutrient Stewardship Certification Program development

The Advisory Committee was intentionally composed of individuals from industry and agencies with a big picture, forward-thinking, and solutions-oriented attitude to bring a broad perspective to the group. To overcome the hurdles associated with a wicked problem, the depth and breadth of participants needed to be broad enough to add knowledge, interconnectedness, and solution-oriented opinions. The agri-businesses, state and federal agencies, research institutions, conservation organizations, and private industries were selected for broad representation and the skills necessary to create a program that was formed from scientific review, was easy to explain, and built on existing best farm management and certification practices to ensure rigor and broad support.

While the adoption of the 4Rs can be encouraged through public policy, marketing campaigns, research and outreach efforts, pledge and certainty programs, or a combination of approaches, certification programs add credibility by verifying the implementation of specific practices. Certifying individuals or entities have been used widely in business (e.g., International Standards Organization (ISO; www.isostandards.com) standards and subsequent certification) to prove that products and/or services are safe, reliable, and of good quality. Individuals with experience in two regional certification-like efforts, Ohio Sea Grant's Clean Marinas Program and Michigan Department of Agriculture's MAEAP, added first-hand expertise in the Advisory Committee meetings.

Because the agricultural industry has become more integrated over the past two decades, there are fewer nutrient service providers reaching more farmers than before. Each nutrient service provider interacts with thousands of acres and hundreds of farmers. The Advisory Committee decided in 2012 that working with the farmers' trusted advisers, the nutrient service providers, rather than directly with farmers, on nutrient management was the most efficient use of resources. Focusing on nutrient service providers meant reaching a larger number of farms, impacting more farm acres, and reducing the number of entities needing to participate in certification.

The Advisory Committee came to consensus about the purpose of the effort. “This voluntary new program provides a consistent, recognized standard for agricultural retailers in Indiana, Michigan, and Ohio where surrounding waters drain into Lake Erie. As regulations are being considered, it's critical retailers and their grower customers adopt best practices to realize long-term improvements” (Ohio Agri-Business Association (OABA), 2016a). Reaching consensus on this goal statement took several meetings and dozens of drafts. A key part of this process was that several influential agricultural leaders courageously admitted that there was a problem and that they needed to move toward solutions. Particular words like voluntary, recognized standard, and long-term improvements helped tame the problem's “wickedness” and created a solutions-oriented space where all stakeholders involved could work. By agreeing to a common goal early in the process, participants were able to focus and build on areas of agreement rather than to dwell on disagreement.

To begin to develop the criteria in the 4R Nutrient Stewardship Certification Standard (Standard) (OABA, 2016c), a sustainability framework, resource concerns, and each of the 4R areas (source, rate, time, and place) outlined (OABA). While the Standard was drafted as part of an initiative to improve the water quality conditions of the

WLEB, it was understood that there was potential for the 4R Program to be adopted in other agricultural areas and care was taken to write the Standard in that context (e.g., using language referencing land grant universities or federal standards).

The Advisory Committee agreed that the Standard should help address the following sustainability goals (OABA, 2016d):

- Maximize crop uptake of nutrients and minimize nutrient losses;
- Create long-term positive impacts on water bodies associated with agricultural production areas, including the reduction of eutrophication and incidence of harmful algal blooms, and helping to meet water quality standards;
- Encourage sharing of up-to-date information about responsible nutrient stewardship with nutrient service providers and growers; and
- Help the agricultural sector adapt to new research and technology in the area of nutrient stewardship.

To reach these goals, the geography, water management, and cropping systems were important to recognize. The WLEB watershed started being drained to eliminate the Great Black Swamp in the 1800s via ditches and subsurface tiling to make the region suitable for business, trade, agriculture, and housing. Approximately 90% of the soils in the WLEB are classified as somewhat poorly drained to poorly drained, requiring subsurface or tile drainage for production practices (USDA, 2016c). While nearly 70% of the 7.2 M acre (2.9 M hectare) watershed is considered farmland, 50% of the watershed is in corn or soybeans in any given year, and approximately 75%–80% of the fertilizer comes from commercial fertilizer (i.e., not livestock manure or sewage sludge). (Ohio EPA, 2013). While most acres have some aspect of nitrogen and phosphorus management, the majority of the acres in WLEB lack consistent use of the 4Rs on each crop in every year of production (USDA, 2016a).

Erosion was the major source of phosphorus to the WLEB in the 1980s but, because of farmers' high rate of adoption of minimal tillage, it has declined (Ohio EPA, 2010). The increase in minimal tillage has led to an increase in broadcast application of fertilizer (Ohio EPA, 2010). Broadcast application is also preferred because broadcast applicators can drive faster through the field, covering more area each day. On average, 500–800 acres (200–320 ha) can be broadcast in eight hours compared to 200 acres (80 ha) if it is injected. Historically, phosphorus was considered immobile on or in the soil with loss linked to soil displacement via erosion. However, recent data indicates that phosphorus left on the surface, when followed by heavy rainfall, can also be a major source of phosphorus loading both in surface flow and in subsurface tile loads (King et al., 2015a, 2015b).

Because of the homogeneity of the crops produced, the limited amount of fertilizer applied via manure, and the focus on addressing the dissolved phosphorus loading, concerns related to specific sources of phosphorus were addressed through criteria related more to placement and timing. Some criteria were difficult to solidify because the science was not conclusive, or not applicable in all situations, or not practical or specific enough to determine how to implement in practice. In developing the criteria to achieve certification in the 4R Program, the Advisory Committee kept coming back to these general statements and developed definitions (e.g., winter, frozen, and snow covered) to ensure a shared understanding.

1. Farming is impacted by weather, which is difficult to plan for using particular dates for nutrient application timing;
2. Across regions, farmers apply nutrients differently because of differences in crop rotation, climate, topography, and soil type;
3. Nutrient service providers only make recommendations and apply nutrients, they do not manage the farm; and
4. The focus is on Lake Erie's water quality and primarily dissolved phosphorus movement.

To ensure transparency and opportunities for input beyond the WLEB, the Advisory Committee contracted with SCS Global Services, a trusted leader in third-party certification development. The third party helped ensure the Standard was written in a verifiable or auditable way, conducted and facilitated a concise open comment period, piloted the audits at four locations, and trained the initial set of auditors. During each step, the Standard and auditing process were modified to reduce redundancy and increase clarity.

4R best practices in the WLEB Nutrient Stewardship Certification Standard

The Standard (OABA, 2016c) has incorporated specific criteria based on the 4Rs nutrient stewardship (Bruulsema et al., 2009), and it follows regional soil fertility recommendations (e.g., Vitosh et al., 2012) and guidelines in the Conservation Practice Standard for Nutrient Management (USDA, 2012). The Standard is divided into three sections:

1. Initial Training and Ongoing Education;
2. Monitoring of 4R Implementation; and
3. Nutrient Recommendations and Application.

Sections 1 and 2 apply to all nutrient service providers; however, parts of Section 3 may not be applicable for those nutrient service providers that either do not make recommendations or do not apply nutrients. There are a total of 41 auditable criteria; seven (7) address Initial Training and Ongoing Education, three (3) address Monitoring of 4R Implementation, and 31 address Nutrient Recommendations and Application.

Unless otherwise specified, 100% of a nutrient service provider's recommendations, application records, or farmer customers must meet the requirements specified in the criteria during every audit year in order to achieve conformance with the Standard. Each criterion is assumed to take effect in Year 1 unless otherwise noted. All criteria take effect by Year 3. The Standard is a fluid document, evaluated bi-annually by the Advisory Committee, with requirements continually adapting and improving as new advancements in research and technology allow. For example, currently, it is required that weather forecasts should be obtained from the National Oceanic and Atmospheric Administration (NOAA) because they have the criteria and credibility, but in the future, there may be other weather forecast tools or affordable technology that helps determine nutrient timing.

One program goal is to "encourage sharing of the most up-to-date information about responsible nutrient stewardship with nutrient service providers and growers". To ensure the credibility of the nutrient service providers and their recommendations, continual agronomic and 4R education is key. The Initial Training and Ongoing Education section helps ensure that the education and training occurs, not just by the nutrient service provider staff, but also with their farmer customers.

The implementation of 4R principles and practices are recorded and monitored, including annual summary totals of nutrients applied and which watershed they operate, at a hydrologic unit code (HUC) 8 level (e.g., St. Joseph River, Sandusky River, Blanchard River). Records of implementation are checked by the auditor to evaluate progress of 4R principle and practice implementation over time.

The Nutrient Recommendation and Application section is the core of the standard. While the Standard does not delineate which of the 4Rs it applies to, as there is overlap among them, it does address each of the 4Rs. Below is a summary of some of the 31 criteria in this section.

Because each farm is managed differently, specific field records are evaluated to review the issue of accurate rate recommendations and uniformity in soil sample information and intervals. Not all soil samples or field records are conducted the same. Some farmers tested their fields every two years, while others conduct tests every five to ten years. Some field records only have the field name and boundary while others have several layers of field data including yield maps, previous fertilizer maps, and soil testing. To achieve 4R Certification, field records must

have the field boundaries, watershed, sensitive areas, yield goals, and current soil tests. The requirement states that a soil test representing at most 25 acres must be taken at least every four years.

Nutrient recommendations must be made using the soil test information and cropping and yield history and account for all sources of nutrients. Because a farmer's exact yield data is not always captured with a yield monitor and is proprietary, the nutrient service provider must rely on the farmer for the yield history. When yield data is shared, the nutrient service provider can make better nutrient recommendations for the farmer.

Agreement on several criteria in this section was challenging, including spreading nutrients on frozen ground, timing of nutrient application prior to a rainfall, and phosphorus placement. Applying nutrients on frozen ground had become more common in the prior 15 years because compaction was less of an issue with the larger spreading equipment, there is more time in the winter to do this activity, and it was thought that once phosphorus touched the soil, it was immobile so it didn't matter as much when phosphorus was applied. While there has not been any significant change in average annual rainfall, there have been significant increases in fall and winter runoff. Reductions in snowfall over this period may be contributing to significant runoff, as a result of frozen ground and little to no plant uptake, even under moderate winter rains. (Ohio EPA, 2010). While Advisory Committee members agreed that nutrients should not be applied on frozen or snow-covered ground, the definition of frozen needed to be clarified. This lengthy discussion helped clarify several criteria related to timing because it was the state of the soil, not the date on the calendar that determined what frozen meant. Frozen ground, for the purposes of the Standard, is when soil conditions are such that tillage or nutrient incorporation and/or injection after application are not possible at the time of nutrient application, and will not be possible within the next 48 h as a result of frozen conditions.

The discussion on applying nutrients to saturated soils followed the same trajectory as the one on frozen soils. Generally, nutrients are not applied if the ground is already saturated because the application equipment would be stuck in the fine clay soils and severely compact the soil. When the soil is saturated, even a small rain event can cause runoff and nutrients leave the field. After consultations with Dr. Kevin King with the U.S. Department of Agriculture—Agriculture Research Service (USDA-ARS) and Dr. Rem Confessor from Heidelberg University, it was agreed that eliminating broadcast nutrients movement during a large rain event, considered to be one inch or more, would reduce nutrient movement. Again, the Advisory Committee agreed that applying nutrients ahead of a large rain event does not follow the 4R Program goals; however, writing criteria to fit that pragmatic application was difficult and awkward. The NOAA forecast was referenced again as the source for reliable data. It was agreed that a NOAA forecast showing more than 50% chance of rainfall would be the tipping point for whether to broadcast apply nutrients or not.

To keep phosphorus in the fields, one best management practice is to incorporate the phosphorus when/wherever possible (e.g., via strip till, vertical till, or chisel plowing) (Ohio EPA, 2010; Smith et al., 2016). Because of the concern with erosion and sedimentation into Lake Erie, reverting to complete tillage to incorporate phosphorus was not defensible. Three options were made allowable when broadcasting phosphorus without incorporation within one week or before the next rainfall event:

a) the field has been in continuous no-till for at least three years, or
b) has a cover crop or growing crop, or
c) the risk for phosphorus loss to surface waters has been demonstrated to be low, according to a NRCS-approved phosphorus index risk assessment procedure.

Research is ongoing related to these three options and, in the future, they may change because more is known related to things such as the soil health of continuous no-till situations, or new technology for nutrient placement.

Certification

To ensure Standard criteria have been met, a private, third-party auditor reviews documentation to evaluate the nutrient service provider's performance, interviews staff responsible for nutrient recommendations and application, and observes nutrient storage, mixing facilities, and application equipment. If a nutrient service provider has multiple locations, separate audits are required to certify each location; therefore, a single company could have multiple locations earning certification.

Following the audit, the auditor prepares a report detailing audit findings. If criteria are not fully met, the nutrient service provider develops a corrective action plan for auditor approval prior to sending the final recommendation and report to the certification body. The Nutrient Stewardship Council, the 4R Program governing body, has a Certification Subcommittee that reviews the audit report and corrective action plan and will issue a certification recommendation to the Nutrient Stewardship Council, which then votes on certification. Confidentiality is a key component to the 4R Program as such, the Certification Subcommittee does not include any Nutrient Stewardship Council members representing an agribusiness.

Governing body

Before launching the 4R Program, the Advisory Committee developed a formal governing structure to ensure consistent and cohesive management, policies, guidance, processes and decisions. On October 30, 2013, the Nutrient Stewardship Council (Council) (OABA, 2016b) was created and in 2014 was granted 501(c)(3) status. As the governing body of the 4R Program, the Council is ultimately accountable for the program's financial health and effectiveness. The Council consists of 11 individuals. Each member must represent one of four different groups:

- Agricultural business (five members, including at least one active grower),
- Government (two members),
- Environmental non-governmental organizations (two members), and
- Universities/research (two members).

The Council reviews all changes to the Standard, publicizes the 4R Program, issues certificates, trains the auditors, and oversees any expansion of the program. The program administrator, Ohio AgriBusiness Association (OABA), conducts the day-to-day operation of the program.

From its inception, the intention was that the 4R Program would become self-sufficient. Currently, each nutrient service provider pays an annual fee of $600 to support operating costs and its own audit fee of approximately $1150. It is unknown how many nutrient service providers exist in the WLEB. With annual costs exceeding $100,000, the 4R Program may need to change its fee structure, increase annual fees, expand its geography, or look for alternative supplemental funding. As of April 2016, private foundations, agribusinesses, and commodity groups had funded the majority of the expenses, but this is not expected for the long term.

4R program impact

Outreach and adoption

The 4R Program was launched on March 18, 2014. By April 20, 2014, 50 nutrient service providers had let OABA know that they wanted to begin the certification process. Achieving certification within the 4R

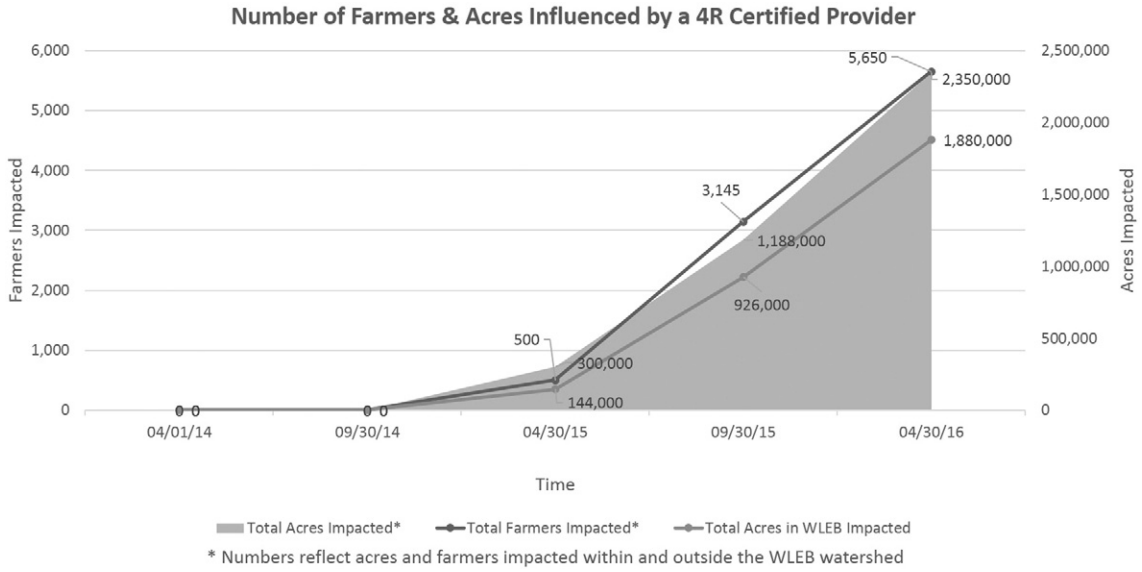

Fig. 1. On the left axis are the number of farmers influenced by 4R Certified providers (over 5000). On the right axis are the number of acres that the 4R Certified providers influence (2.35 million in total, 1.8 M in the WLEB (1 acre = 0.4 ha)). All numbers are as of April 30, 2016. Note that not all acres or farmers are located in the Western Lake Erie Basin as a nutrient service provider may service clients and acres in the Lake Erie or Ohio River watershed as well.

Program is not easy and requires more record-keeping than nutrient service providers typically maintain. As this new program was introduced to agricultural business leaders throughout the WLEB, continual education and outreach efforts about the 4Rs and the 4R Program were necessary.

To better inform participants, The Nature Conservancy and Ohio Agribusiness Association, contracted an outreach person to conduct pre-audit visits with participants. This one-on-one interaction has been coupled with agricultural industry meetings where the 4R Program, research and Lake Erie health information is shared.

By April 2016, two years after the program launched, 30 nutrient service provider facilities had earned 4R certification, influencing nutrient management on 2,350,000 acres (5 M ha) in total with about 35% impacted located in the WLEB watershed (Figs. 1 and 2). 4R Certified providers impact all farmers they advise regardless of the watershed they farm in, which is why there are approximately 550,000 acres (223,000 ha) and 1650 farmers outside the WLEB watershed that are impacted through the 4R Program. Other regions and states have expressed interest in the program and expansion into the Ohio River basin is being pursued.

Evaluation of the 4R Nutrient Stewardship Certification Program

Evaluating the 4R Program's impact is a continual effort. Guided by several individuals on the Council and three research institutions, the USDA-ARS received a five-year grant from the 4R Research Fund (http://www.nutrientstewardship.com/4r-research-fund) to evaluate the 4R Program. The overall goal is to evaluate specific impacts of 4R practice adoption and the impact of the 4R Program itself on crop productivity and profitability, water quality, and perceptions of growers, nutrient service providers, and residents in the WLEB. This multidisciplinary approach involves monitoring, modeling, and measurement of

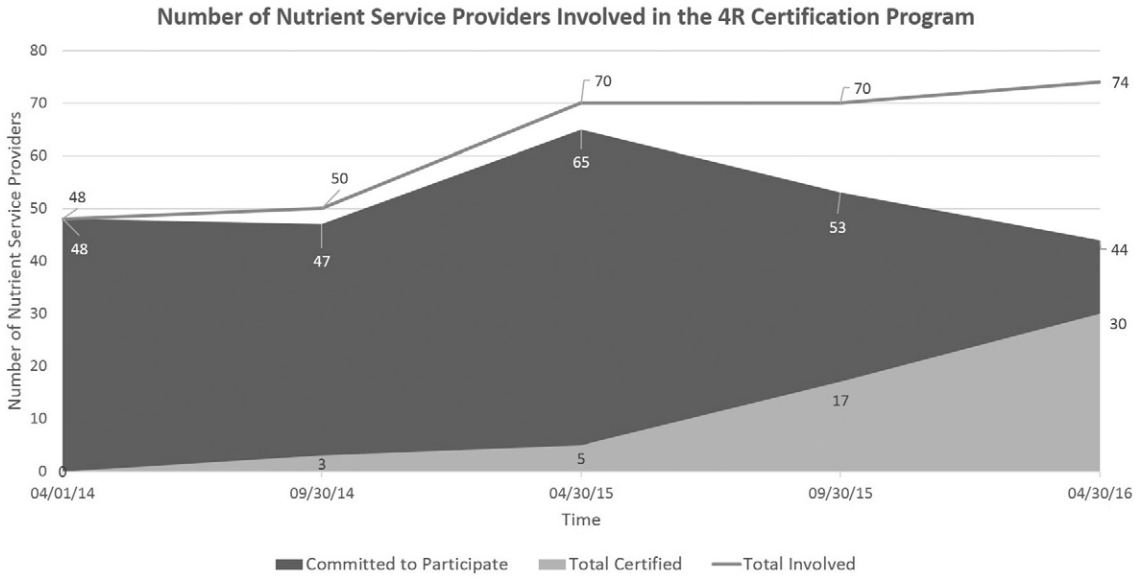

Fig. 2. The number of nutrient service providers committing to the 4R Certification Program has increased to 74, with 30 becoming 4R Certified as of April 30, 2016. As nutrient service providers become certified, the number of applications and audits will decrease unless more applications are received.

the impacts at the field, watershed, and lake scales. The impact to Lake Erie and HABs will be estimated, but because of unknown response times from the infield nutrient practices, results may not be visualized in Lake Erie for years. Below are the goals for the evaluation to be completed by July 2019 (4R Research Fund, 2014):

1. Monitor the impacts of 4R Nutrient Stewardship practices and the 4R Nutrient Stewardship Certification Program on crop productivity, nutrient losses, and biotic integrity from select fields, streams, and watersheds in the WLEB.
2. Model the environmental benefits in Lake Erie (turbidity and HABs) following various levels of implementation of 4R Nutrient Stewardship practices and the 4R Nutrient Stewardship Certification Program in three WLEB agricultural watersheds.
3. Determine the behavioral impact of 4R educational efforts and the 4R Nutrient Stewardship Certification Program on the knowledge, beliefs, and management practices of crop growers and nutrient service providers in the WLEB.
4. Conduct a triple bottom line evaluation of the economic, social, and environmental performance of the 4R Nutrient Stewardship Certification Program in the WLEB.
5. Integrate information from all the above to develop indicators for continued public reporting of progress and guide the 4R Nutrient Stewardship Certification Program.

Influence of the 4R advisory committee and certification program

While quick results are preferred, in the natural setting, rarely is there an immediate response to changes in the landscape. Because unmanaged nutrient applications may increase nutrient losses, potentially degrading water and air quality in a number of ways (Bruulsema et al., 2009), supporters of the 4R Program believe strongly that 4R certification of nutrient service providers will be a positive impact on Lake Erie. The Council has a goal of 80% market penetration in the WLEB. The goal of the International Joint Commission, Ohio Governor, Michigan Governor, and Ontario's Premier is to reduce the dissolved reactive phosphorus spring load by 40% (International Joint Commission, 2014; CGLSLGP, 2015). The 4R Program will be evaluated for its relative contribution toward this goal—again recognizing that, as a wicked problem, any one solution alone cannot achieve this goal. 4Rs alone will not be enough to meet the goals of reducing the off-site transport of nutrients (USDA, 2016a). Precision conservation needs to be merged with precision farming (Delgado and Gantzer, 2015). Precision conservation includes implementing conservation in the right places at the right scale, such as no-till, winter cover crops, grass waterways, filter and buffer strips, drainage water management, and treatment wetlands. If farmers and agribusinesses are to address nutrient transport, water movement must also be addressed, whether surface or subsurface flow.

HABs are considered to be one of the most significant issues threatening water quality in the Great Lakes Basin, and Lake Erie in particular (Dove and Chapra, 2015; Londo et al., 2015). Public outcry concerning the presence of HABs and their perceived causes have been increasing over time, and reached a crescendo with the 2014 Toledo drinking water ban that affected nearly half a million people (Richards et al., 2002; Londo et al., 2015). Federal and state legislation was introduced immediately (OH SB356, introduced August 14, 2014, 130th General Assembly). Ohio's general assembly reviewed the 4R Certification Standard and while 4R Program requirements were not intended for legislation, two criteria (3.5.7 and 3.5.8) from the Standard were inserted into Senate Bill 1 (OH SB1, introduced February 2, 2015, 131st General Assembly). This legislation was signed into law on April 2, 2015. Contrast this legislation with four years earlier, when Ohio revised its rules for a watershed in distress which eliminated spreading nutrients during specific timeframes regardless of weather or soil conditions. The inflexibility and definitions of the previous legislation were not farmer friendly. This voluntary certification program provided a collaborative interdisciplinary platform to develop standards that are practical to implement on farms and should be ecologically effective. In this case, good policy followed from an effective voluntary approach and there was broader political support for the legislation. And as state and federal regulators scrutinize agricultural activities in the WLEB, being 4R Certified shows farmers that their nutrient service providers are meeting not only legal requirements but are also going beyond the minimum legal requirements to keep nutrients in the fields to grow crops.

Voluntary programs are only as successful as the rate of implementation (USDA, 2016a). This 4R Program has impacted 35% of the farmland in the WLEB in just two years (Fig. 3). The Advisory Committee and Council members have been integral to the 4R Program's success, both in meeting discussions and in gaining program support with

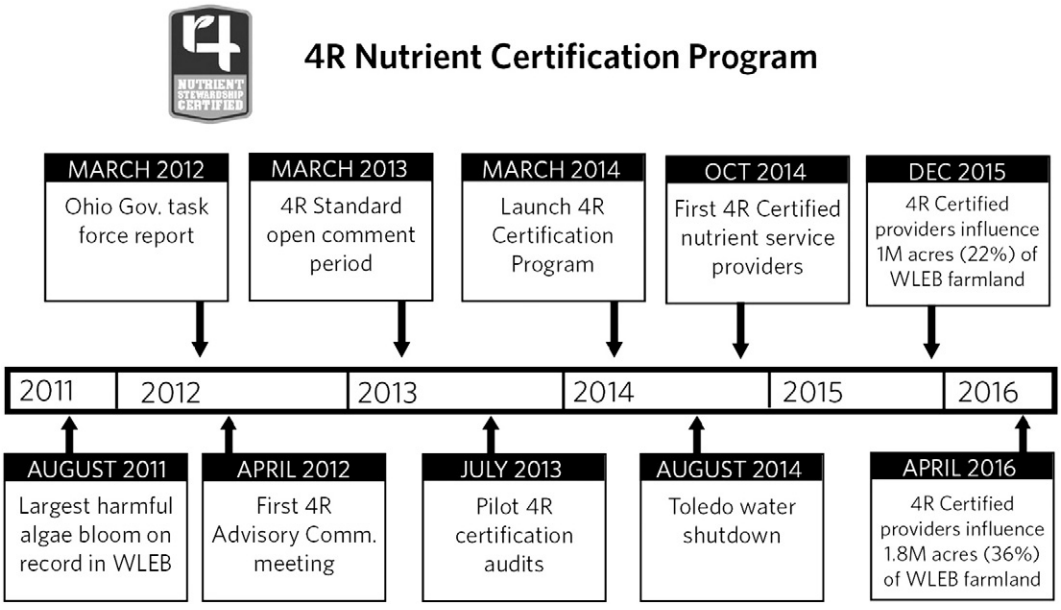

Fig. 3. The timeline of the 4R Certification Program from influencing circumstances, design, pilot, and launch through two years after launch, through April 30, 2016.

their farmer customers, colleagues, and members. When a concerned farmer or agribusiness person can talk with conservation program managers whom they trust, the credibility and support for the 4R Program is much stronger. Grounding the discussion in science and continually evaluating economic, social, and environmental factors helped to keep the Advisory Committee engaged. No single Advisory Committee member controlled the outcome of the 4R Program. Shared ownership means that no single person will be critical to the success or failure of this program in the future. With increased psychological ownership from within the agricultural community, the prognosis is for sustained promotion of the 4R Program and expanding voluntary adoption of responsible nutrient management.

There are many ways farmers and agribusinesses can support the 4R nutrient stewardship effort, for example, becoming a 4R partner or implementing the 4Rs. The Advisory Committee and Council members and their colleagues continue to support the 4R Program by incorporating various outreach efforts in everyday operations. The American Society of Agronomy added accredited classes for certified crop advisers related to 4R nutrient stewardship and water quality. State government has offered 4R Certified nutrient service providers incentive payments for each farmer they help become verified in Michigan's farmer assurance program, MAEAP. In addition, a nutrient manufacturer offers its retail distributors a cost-share rebate for the audit, if they earn certification under the 4R Program.

Conclusion

Lessons learned from the 4R Advisory Committee & 4R Program

In 2011, the largest HAB on record generated much public attention and brought the agricultural and conservation community together to discuss solutions. To overcome the hurdles associated with the wicked problem, the depth and breadth of key stakeholders needed to be broad enough to add knowledge, interconnectedness, and solution-oriented opinions and open enough to listen to others.

It took time, honest conversation, and openness to build trust and respect between individuals, especially those with varying backgrounds and goals. This trust was essential to collaboration to address this wicked problem. While it was important to have particular entities involved when creating the 4R Nutrient Stewardship Certification Program, individuals with a big picture, forward-thinking, and solutions-oriented attitude helped bring a broad perspective to the group. While any single organization could have created a nutrient management program, it would not have been as robust, as practical, or as accepted as the one created by the broad group of stakeholders involved with the Advisory Committee. If this 4R Program is expanded to other watersheds, an advisory committee with the right individuals from a broad constituency must be at the table to first build trust and ultimately own their 4R Program within their geography.

The Advisory Committee realized during the program planning that continual evaluation of 4R Program requirements would be necessary. Due to the ongoing research within the agricultural, water quality, and technologic fields, adaptive management and continual improvement has already proven necessary to the success of the 4R Program. While it is important to design the program to be effective based on existing knowledge, it is equally important to evaluate the results and make revisions to improve the 4R Program over time. It is impractical to attempt to solve every nutrient challenge through a certification program. Because this program focused on the water quality impacts of nutrients, nutrient storage and safety were not included in the standard. This focus has helped keep the standard relatively short (41 criteria), simplified evaluation of the 4R Program's water quality impact, and allows for easier transferability to other geographies.

Voluntary programs are only as strong as the rate of participation. The 4R Program has grown to impact 35% of the farmland in the WLEB in just two years. Because of the interest from nutrient service providers, the leadership and ownership from the farmer, commodity, and agribusiness groups and the broad support from government, environmental, and research institutions, this voluntary program could impact nearly all farmland in the WLEB. The 4R Program will be evaluated for its relative contribution toward the HAB reduction goal—again recognizing that, as a wicked problem, any one solution alone cannot achieve this goal. 4Rs alone will not be enough to meet the goals of reducing the off-site transport of nutrients.

The 4R Nutrient Stewardship Certification Program is a practical way to ensure the 4Rs are being implemented. Nutrient management practices and water quality awareness is progressing in the WLEB. The rigor, structure, governance, and credibility of the 4R Program make it a candidate to help in other regions with wicked problems related to nutrient management. While agriculture is a contributor, it is not the only source of nutrients in the WLEB. All sectors of society must work together to develop a comprehensive solution to this shared problem and there will likely be a significant period of time before the benefits of these efforts are measurable at a regional scale (USDA, 2016b).

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