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Abstract: Harmful algal blooms in the Western Lake Erie Basin (WLEB) can be considered a wicked problem - there is conflicting interpretations of the problem and science, stakeholders have different values and goals, and there is no definitive solution. This paper outlines how agribusiness, research, government, and environmental groups came together to create the 4R Nutrient Stewardship Certification Program to help reduce nutrient loss to Lake Erie.

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 whilst considering the environment, society, and economics. The voluntary 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. Just 20 months since the 4R Certification program's launch, over 20% of WLEB's farmland is influence by one of 23 4R Certified providers.

Beyond certification, the greatest success of this program is that agribusinesses are making the scientific connection behind why agriculture needs to act. Armed with this knowledge, we can take steps to help keep nutrients in the field to grow our food, not algae. Nutrients and water are being thought about differently, action is taking place, and nutrient management has been taken to a new level. 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.

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Cover Letter

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December 30, 2015

Dear Dr. Hecky,
I am writing to submit our manuscript entitled, "Building Partnerships to Scale Conservation: 4R Nutrient Stewardship Certification Program in the Lake Erie Watershed." This manuscript is an invited submission for the special issue of JGLR focused on research in Great Lakes watersheds dominated by agricultural land use.

Our manuscript discusses the wicked problems of Lake Erie's algal blooms and how a diverse group of stakeholders came together to develop a program to reduce nutrients entering Lake Erie from farm fields. Managing nutrients in field is the most basic step to addressing nutrient loss.The 4R Nutrient Stewardship Certification Program audits farmers' trusted advisers, the agribusinesses, crop advisers, and nutrient service providers on recommendations and implementation of the 4Rs. The 4Rs refer to the Right source of fertilizer is being applied at the Right rate at the Right time and in the Right place.

Just 20 months after launching the 4R Certification program, over 20% of the farmland acres in the Western Lake Erie basin are influenced by a 4R Certified provider. Results at scale have the potential to significantly influence Lake Erie and agriculture business practices related to nutrient management and water quality.

The information and model program is being discussed in other states, including Iowa, Illinois and Kentucky to help bring agricultural, conservation and research institutions together to discuss the best 4R nutrient stewardship practices for the climate, soil, and management conditions. Understanding the approach we developed, which is highlighted in this manuscript, can help the program and nutrient management changes be replicated.

This manuscript describes original work and is not under consideration by any other journal and all of the authors approved the manuscript and this submission.

Thank you for receiving our manuscript as part of this special issue. We appreciate your time and look forward to the response of you and the guest editors.

Sincerely,

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Title:

Building Partnerships to Scale Conservation: 4R Nutrient Stewardship Certification Program in the Lake Erie Watershed

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Introduction

Harmful algal blooms in the Western Lake Erie Basin (WLEB) can be considered a wicked problem. Stakeholders facing wicked problems have conflicting interpretations of the problem and the science behind it, as well as different values, goals, and life experiences. Accordingly, policy makers, public health professionals, and other stakeholders who grapple with these problems cannot expect to effectively resolve them by relying solely on expert-driven approaches to problem solving (M.W. Kreuter, et. al., 2004). Wicked problems cannot be solved per se, but can get better or worse (Batie, 2008). Wicked problems, defined by the criteria below, have no definitive solution and require practical approaches with many stakeholders to effectively address and improve the situation (Batie, 2008).

1. No clear definition of the problem and the problem changes overtime;

2. Incomplete knowledge and scientific data available;
3. The problem is connected with other problems with no definitive solution; and
4. Values differ among stakeholders and outcomes have uncertainty.

The severe, harmful algal blooms 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 (D. Smith, et.al, 2015) (Figure 1).

Water quality research in the WLEB has been conducted for decades by Heidelberg University and others. However, gaps still exist in understanding which stream reaches or watersheds contribute nutrient loads most significant to growth of the blue-green algae (cyanobacteria) that generate the harmful algal blooms (HAB) in WLEB. Cyanobacteria blooms are limited by the amount of available phosphorus. 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 and 2015b). In the WLEB, 70% of the watershed is considered farmland and between 60-100% of the farmland is subsurface drained. (Ohio EPA, 2013) (Figure 2).

As more information is generated with ongoing research both in the lake and in the watershed, an increasing number of opinions are surfacing on how to address the challenge. Conservation practices that have worked in the past may not be as effective with increasing rainfall intensities (Hall et. al, this issue). Practices addressing total phosphorus and nitrogen entering the streams may not address dissolved reactive phosphorus (DRP), the phosphorus form identified with increasing and limiting the HAB size (Baker, 2011). Many solutions to the HAB problem have been suggested, and 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 and Ohio EPA 2013).

While any one of these may be appropriate at different times and places, it will undoubtedly require a combination of solutions across the entire watershed to meet the currently accepted nutrient reduction goals. Regardless, agricultural nutrient management, specifically, managing

nutrient inputs onto farm fields, remain a major component of addressing the system-wide nutrient issues (Kietzer, et.al, this issue).

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 2,000 mi^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 community together to discuss solutions. In this paper we provide an overview and lessons learned of one such solution: the concept of 4R nutrient stewardship through the development and implementation of the 4R Nutrient Stewardship Certification Program (4R Certification Program) in watersheds that feed the WLEB.

Origins and History of 4R

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 (Figure 3). To achieve those goals, the 4R concept provides guidelines to ensure that soil fertility is maintained and losses from the site are minimized by using the:

- Right nutrient source at the
- Right rate, at the
- Right time and in the
- Right place

4R nutrient stewardship is the implementation of best management practices (BMPs) to optimize the efficiency of fertilizer use. The goal of fertilizer BMPs is to match nutrient supply with crop requirements and to minimize nutrient losses from fields. Selection of BMPs varies by location, and those chosen for a given farm are dependent on local soil and climatic conditions, crop, management conditions and other site specific factors. Properly managed fertilizers can increase profitability and decrease nutrient losses that would potentially degrade water and air. 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 solution to a wicked problem, and proactively created the

4R Nutrient Stewardship Advisory Committee (Advisory Committee) (Appendix A) and subsequently launched 4R Certification Program.

4R Nutrient Stewardship Certification Program Development

Adoption of the 4Rs can be encouraged through public policy, marketing campaigns, research and outreach efforts, pledge campaigns or a combination of approaches. Certification and recognition of proper practices provides another way of encouraging 4R nutrient stewardship adoption. The certification and recognition approach has been used widely in business to provide guidance on best practices and awareness of voluntary participation.

To discuss pathways for increasing 4R adoption in the WLEB a 4R Nutrient Stewardship Advisory Committee was formed. The committee members were not selected at random. Each person was identified as a leader in their industry, with a big picture, forward thinking, and solutions-oriented attitude to bring a broad perspective to the group. To overcome some hurdles wicked problem face, the depth and breadth of participants needed to add knowledge, interconnectedness and solution-oriented opinions. The agri-businesses, state and federal agencies, conservation organizations and private industries were selected for broad representation and skills necessary to create a program that was science-based, easy to explain, and built on existing certification best practices to ensure rigor and broad support.

The Advisory Committee met monthly for two years to assess and develop the audience, science, and certification process; to seek outside expert opinion; to raise program support funds; and to launch the program (Figure 4). Before deciding on a certification program, the Advisory Committee discussed the possibility of a pledge program, a certainty program, and a farmer-centered program like the Michigan Agriculture Environmental Assurance Program (Vollmer-Sanders, 2011).

The Advisory Committee developed the following mission statement. “The Advisory Committee is providing guidance and direction for a consistent, recognized program for the agricultural retailers, service providers and crop advisers that ensures social, environmental and economic 4R nutrient sustainability goals are adopted which lead to long-term positive impacts on water quality in the WLEB.” When dealing with wicked problems, the Australian government published that focusing on incremental pieces (guidance and direction for a consistent recognized program) is more effective than trying to solve the entire issue at once

(http://www.apsc.gov.au/__data/assets/pdf_file/0005/6386/wickedproblems.pdf, December 10, 2015, Australian Public Service Commission, 2007).

Certification to encourage 4R nutrient stewardship could take place at a number of places within the food production supply chain including farmers, fertilizer sales, fertilizer applicators, grain merchandisers and food processors. Farmers purchase their nutrients and often receive nutrient recommendations from agricultural retailers with services from certified applicators. The agricultural retailers, nutrient applicators, and crop advisers, who the Advisory Committee generally called nutrient service providers, are the entities farmers trust when making nutrient management decisions. In Michigan, 70% of the farmers identified fertilizer dealers as a source of information on nutrient management and 30% sited this same group as the most important source of information when making nitrogen fertilizer application rate decisions (Stuart, 2014). Nutrient retail locations are state-licensed for the sale of fertilizer and pesticides; there are hundreds of them in the western basin of Lake Erie, and their transactions involve thousands of acres and hundreds of farmers. The Advisory Committee decided that working with the farmers' trusted advisers or 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.

Discussions regarding program need varied, but ultimately the Advisory Committee agreed that "The 4R Certification Program represents an effort by industry to be proactive, using a scientific approach to nutrient management and sustained crop production, while avoiding regulations that might otherwise be put in place." Reaching consensus on this goal statement helped tame the problem "wickedness" and created a space where all stakeholders involved could work. The 4R Nutrient Stewardship Certification Standard (Standard) (Appendix B) was drafted as part of an initiative to improve the watershed conditions of the WLEB, lying within portions of Indiana, Michigan, and Ohio, with the long-term goal of developing a 4R certification for potential implementation in other United States agricultural areas. The Standard was created to address the following goals:

- 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.

Using previously conducted research and current data sources, the Advisory Committee summarized the science and outlined certification criteria based on right source, rate, time and place. Some discussions were difficult because the science was not conclusive, not applicable in all situations, or not practical or specific enough to determine how to implement in practice. In developing the criteria to achieve 4R Certification, the following statements helped guide controversial discussions and definitions of commonly used terms became necessary (fall, winter, frozen, snow covered, etc).

1. Farming is impacted by weather which is difficult to plan for using particular dates for nutrient application timing;
2. Various regions apply nutrients differently because of 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 Advisory Committee, SCS Global Services was contracted to guide development of the certification standard. SCS Global Services, a trusted leader in third-party certification development, helped ensure the standard was written in an auditable way, conducting a facilitated and concise open comment period and performing four pilot audits to assess the standard. During each step, the Standard and auditing process was modified to reduce redundancy among the criteria and to increase clarity.

Governing Body

Before launching the 4R Certification 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 (NSC) (Appendix C) was created and in 2014 was granted 501(c)(3) status. As the governing body of the 4R Certification Program, the NSC is ultimately accountable for the program's financial health and effectiveness. As such, they are responsible for:

- Detailing and revising governance approaches related to the standard as needed;
- Approving any revisions to the standard and to the audit process;
- Selecting and contracting a program administrator(s);
- Accrediting third-party auditors;
- Identifying core funding for program administration;
- Regularly considering program effectiveness and making decisions regarding substantive changes needed to improve program administration or audit processes; and
- National and regional promotion of the program.

The NSC consists of 11 individuals. Each member may serve two consecutive, three year terms before leaving the NSC, with term limits staggered for the first council members. Each member must represent one of four different groups:

- Agricultural Business (five members, including at least one active grower),
- Government (two members),
- Environmental NGOs (two members), and
- Universities/Research (two members).

The NSC reviews significant changes being considered for the program, for example, decisions related to how to administer, expand, and publicize the program. The program administrator, Ohio AgriBusiness Association, conducts the day-to-day operation of the program.

Certification Standard

The Standard (Appendix B) 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 (NRCS, 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 only make recommendations for nutrient use or only apply nutrients. There are a total of 41 auditable criteria; seven address Initial Training and Ongoing Education, three address Monitoring of 4R Implementation, 31 address Nutrient Recommendations and Application.

Unless otherwise specified, 100% of a nutrient service provider's grower customers must meet the requirements specified by the auditable evaluation criteria during every audit year in order to achieve conformance with the Standard. Year 2 or Year 3 auditable evaluation criteria become mandatory on the year specified and for all subsequent years. The Standard is a fluid document, evaluated annually, continually adapting and improving as new advancements in research and technology prescribes.

Onsite audits consist of a documentation review necessary to evaluate the nutrient service provider's performance against the Standard, interviews with staff responsible for nutrient recommendations and application, as well as a general review of nutrient storage and 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 will prepare a report detailing audit findings. If criteria are not fully met, the nutrient service provider must develop a corrective action plan for auditor approval prior to sending the final recommendation to the certification body. The NSC Certification Subcommittee reviews the audit report and corrective action plan and will issue a certification recommendation to the NSC, which then makes a final decision on certification.

4R Best Practices in the WLEB Nutrient Stewardship Certification Standard

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 recommendations and staff, agronomic and 4R education is key. These three criteria (of the seven in this section) help ensure continual education and training, not just of the nutrient service provider staff but also their grower customers.

1.1.1 Nutrient Service Providers, sales, and application staff have undergone an initial training and staff are able to demonstrate knowledge about 4R Nutrient Stewardship and the 4R Certification Program.

1.2.1 Certified professionals must have current certification in good standing.

1.3.1 Nutrient Service Provider has conveyed informational materials on 4R Nutrient Stewardship to all grower customers. (YEAR 2 REQUIREMENT)

The implementation of 4R principles and practices are recorded and monitored, including annual summary totals of nutrients applied. Records of implementation are checked by the nutrient service provider to evaluate progress of 4R principle and practice implementation over time. While many records are reviewed by the auditor, below are two of the four from the Monitoring of 4R Implementation section that help the NSC determine the impact to the HUC 8 watershed (e.g., St. Joseph River, Sandusky River, Blanchard River).

2.1.1 Nutrient Service Providers will record a list of grower customers and number of acres which are fully serviced and those acres that receive only recommendations and/or custom application.

2.1.2 Field records related to monitoring of 4R implementation must include information about the watershed where the farms are located. (YEAR 3 REQUIREMENT)

The Nutrient Recommendation and Application section is the core of the standard. 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. Manure nutrients also contribute to the water quality; however this source of nutrients was not the primary focus of the Standard because of nutrient service provider's limited role in manure management. Below are six of the 31 criteria in this section of the Standard.

3.1.6 For applications made by the Nutrient Service Provider, records of nutrient application include at minimum:

- method of application;
- time of application;
- a field map showing locations of application;
- weather (temperature and precipitation) conditions at the time of application; and

- weather forecast for the day after application. For the purposes of the Standard, the weather forecast should be obtained from National Oceanic and Atmospheric Administration (NOAA) (2013). (YEAR 2 REQUIREMENT)

3.3.2 Soil tests are conducted at least once every four years.

3.5.3 All sources of nutrients are accounted for in the nutrient management recommendation, including but not limited to commercial fertilizers, manure, biosolids, cover crops, and the previous crop.

3.5.6 Broadcast phosphorus applications without incorporation within one week or before the next rainfall event are not recommended unless

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.

3.5.7 Broadcast applications of nitrogen and phosphorus without immediate incorporation are neither made nor recommended unless the NOAA forecast indicates less than a 50% chance of a rainfall event involving more than an inch of rain beginning in the next 12 hours. At least 80% of the total farm acres treated by nutrient service provider must meet Criterion 3.5.7. (YEAR 3 REQUIREMENT)

3.5.8 Phosphorus applications are neither made nor recommended to be made on frozen or snow covered ground.

Program Impact

Outreach and Adoption

The program was launched on March 18, 2014. By April 20, 2014 50 nutrient service providers had pledged to become certified. Achieving 4R certification within the 4R Certification 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 Certification Program were necessary.

To better inform participants, the NSC contracted an outreach person to conduct pre-audit visits with participants. This one-on-one interaction has been coupled with agricultural industry

meetings where information is shared related to the 4R Certification Program, the latest research in nutrient management and the health of Lake Erie.

In less than two years after the program launched, 23 locations have earned 4R certification, influencing nutrient management on 1,569,000 acres in total and 22% of the farm land in the WLEB (Figure 5 and Figure 6). 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 program impact is a continual effort. A plan to evaluate the 4R Certification Program's water quality impacts to streams and Lake Erie was developed with input from several partners including: United State Department of Agriculture – Agricultural Research Service, International Plant Nutrition Institute, The Ohio State University, Heidelberg University, LimnoTech, The Nature Conservancy, The Andersons, Inc. and several other agri-businesses. The overall goal is to evaluate specific impacts of 4R practice adoption and the impact of the 4R Certification 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 the impacts at the field, watershed, and lake scales. Below are the goals of the evaluation program, to be completed by July 2019:

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 & 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 (Bruuslema et al., 2009), supporters of the 4R Certification Program believe strongly that 4R certification of nutrient service providers will be a positive impact to Lake Erie. The NSC 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 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 reduce the off-site transport of nutrients. Precision conservation needs to be merged with precision farming (Delgado, 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.

On August 2, 2014, microcystin toxin produced by the cyanobacteria entered Toledo's drinking water which led to a 48-hour drinking water ban for the City of Toledo and surrounding areas, affecting more than half a million people. While HABs are chronic, this recent event generated significant media attention, public familiarity with the problem, and a demand for solutions. Legislation was introduced immediately at the federal and in the state of Ohio (OH SB356, introduced August 14 2014, 130th General Assembly). Ohio's general assembly reviewed the 4R Certification Standard and while not intended for regulation, took two criteria (3.5.7 and 3.5.8) from the standard and inserted them into Senate Bill 1 (OH SB1, introduced February 2, 2015, 131st General Assembly). This legislation was signed into law on April 2, 2015. If the agricultural community had not already vetted the science and created clear criteria in the 4R Certification Standard, there may not have been agreement amongst the agricultural and conservation groups, emotions could have overridden the discussions, and the law would not be as flexible. Four years earlier, Ohio passed Senate Bill 150 which eliminated spreading nutrients

during specific timeframes regardless of weather or soil conditions and was less user friendly. As state and federal regulators scrutinize agricultural activities in the WLEB, being 4R Certified could provide nutrient service providers with a line of defense against legal or regulatory actions, albeit a designation currently lacking in legal authority.

The Advisory Committee and NSC members have been integral to the 4R Certification Program's success, both in meeting discussions and in gaining program support with their grower customers, colleagues and members. When a concerned farmer or agri-business can talk with multiple people they trust, the credibility and support for the program is much stronger. Grounding the discussion in science and not driving the conversation in a specific direction has helped keep the Advisory Committee engaged. No single Advisory Committee member controlled the outcome of the 4R Certification Program. Ownership will be critical to the promotion of this program in the future. With increased ownership within the agricultural community, there will be increased promotion of the program and subsequently increased support and adoption.

There are many ways to support the 4R nutrient stewardship effort, for example becoming a 4R partner or implementing the 4Rs on your farm or in your business. The Advisory Committee and NSC members and their colleagues continue to support the 4R Certification 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 Certification Program.

Discussion

Lessons Learned from the 4R Advisory Committee & Certification Program

In 2011, the largest HAB on record generated much public attention and brought the agricultural and conservation community together to discuss solutions. Because the discussions were not shrouded by lawsuits or federal regulations, when the Advisory Committee first met it was awkward but productive.

It takes time, honest conversation, openness and socializing to build trust and respect between individuals, especially those with varying backgrounds and goals. This trust is essential to moving forward with this kind of approach addressing wicked problems. While it was important to have particular entities involved when creating the 4R Certification Program, reaching out to the wrong person or not including some individuals from the beginning could have stifled progress and eliminated ecological advancement for years. 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 Advisory Committee. If this program is expanded to other watersheds, an advisory committee with the right people from a broad constituency must be at the table to first build trust and ultimately own their 4R Certification Program within their geography.

As the old adage goes, proper preparation prevents poor performance. The pre-audit visit and the educational sessions have been critical to prepare the nutrient service provider for the audit, and is critical for their success in becoming certified under the 4R Certification Program. Feedback from both the auditor and the nutrient service provider suggest that entities that have a pre-audit are more prepared for the audit both regarding recordkeeping and general audit criteria requirements. While the Program began with one part-time outreach coordinator, a full time contractor is now needed to fill the outreach and support demand.

Adaptive management and ongoing improvement has already proven necessary to the success of the 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 program over time. It is impractical to attempt to solve every nutrient challenge through a certification program. By focusing 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 Program's water quality impact, and allowed for easier transferability to other geographies.

The intention is that the 4R Certification Program becomes self-sufficient by 2019. Currently, each nutrient service provider pays an annual enrollment fee of $600 and the pass-through audit fee of $1,150. It is unknown how many nutrient service providers exist in the WLEB. With annual costs exceeding $100,000, the program may need to increase annual fees or look for

alternative supplemental funding. Thus far, private foundations, agribusinesses and commodity groups have funded the majority of the expenses.

Conclusion

Harmful algal blooms in the WLEB are a wicked problem with many solutions. Through programs like the 4R Nutrient Stewardship Certification Program, the wicked problem can be tamed. 4R nutrient stewardship provides the foundation as a science-based framework to achieve sustainable plant nutrition management considering the environment, the community and economics. Significant reductions in the amount of nutrients entering our freshwaters can be achieved by ensuring nutrients are applied correctly.

A certification program offered a way to take this framework and formalize it into a program that could be implemented, and where that implementation could be evaluated and reported. While it only took two years to develop this Program, it will continue to make a difference to Lake Erie for decades to come.

With the population ever-growing, we need to ensure a sustainable food supply and an abundance of drinkable, fishable water. Supporting the 4R Nutrient Stewardship Certification Program is supporting the implementation of best management practices for nutrients. Even if all the agricultural acres in the WLEB were managed following the 4Rs, harmful algal blooms will not be eliminated; but it is a necessary, critical piece to helping lessen this wicked problem. The 4R Nutrient Stewardship Certification Program is a practical way to ensure the 4Rs are being implemented. When the right people come together and act on an agreed goal, programs like this can flourish.

Beyond the certifications themselves, the largest success of this program, is that the agribusiness community is hearing, some for the first time, the scientific connection behind why agriculture needs to act and what steps farmers and agribusinesses can take to help keep nutrients in the field and out of the streams and lakes. Nutrients and water are being thought about differently, action is taking place, and the nutrient management has been taken to a new level. The rigor, structure, governance and credibility of the 4R Certification Program make it a candidate to help in other regions with wicked problems related to nutrient management.

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Figure Captions:

Figure 1: Annual loadings, including sources of total phosphorus to Lake Erie, 1967 – 2007. Graph prepared by David Baker (Ohio EPA, 2010).

Figure 2: Land use in 2014 in the Western Lake Erie Basin watershed.

Figure 3: 4R nutrient stewardship provides a framework to achieve cropping system goals, such as increased production, increased farmer profitability (economic), enhanced environmental protection (environmental) and improved sustainability (social). The 4Rs stand for the Right fertilizer source at the Right rate, at the Right time and in the Right place.

Figure 4: The timeline of the 4R Certification Program from design, pilot, and launch, and through 20 months after launch.

Figure 5: On the left axis are the number of farmers influenced by 4R Certified providers, nearly 4,000. On the right axis are the number of acres that the 4R Certified providers influence, just over 1.5 million. Both numbers are as of December 30, 2015. 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.

Figure 6: The number of nutrient service providers involved in some way with the in the 4R Certification Program has increased to 70. As nutrient service providers become certified, the number of applications and audits will decrease unless more applications come in. There have been 23 audits as of December 30, 2015.

Figure 1

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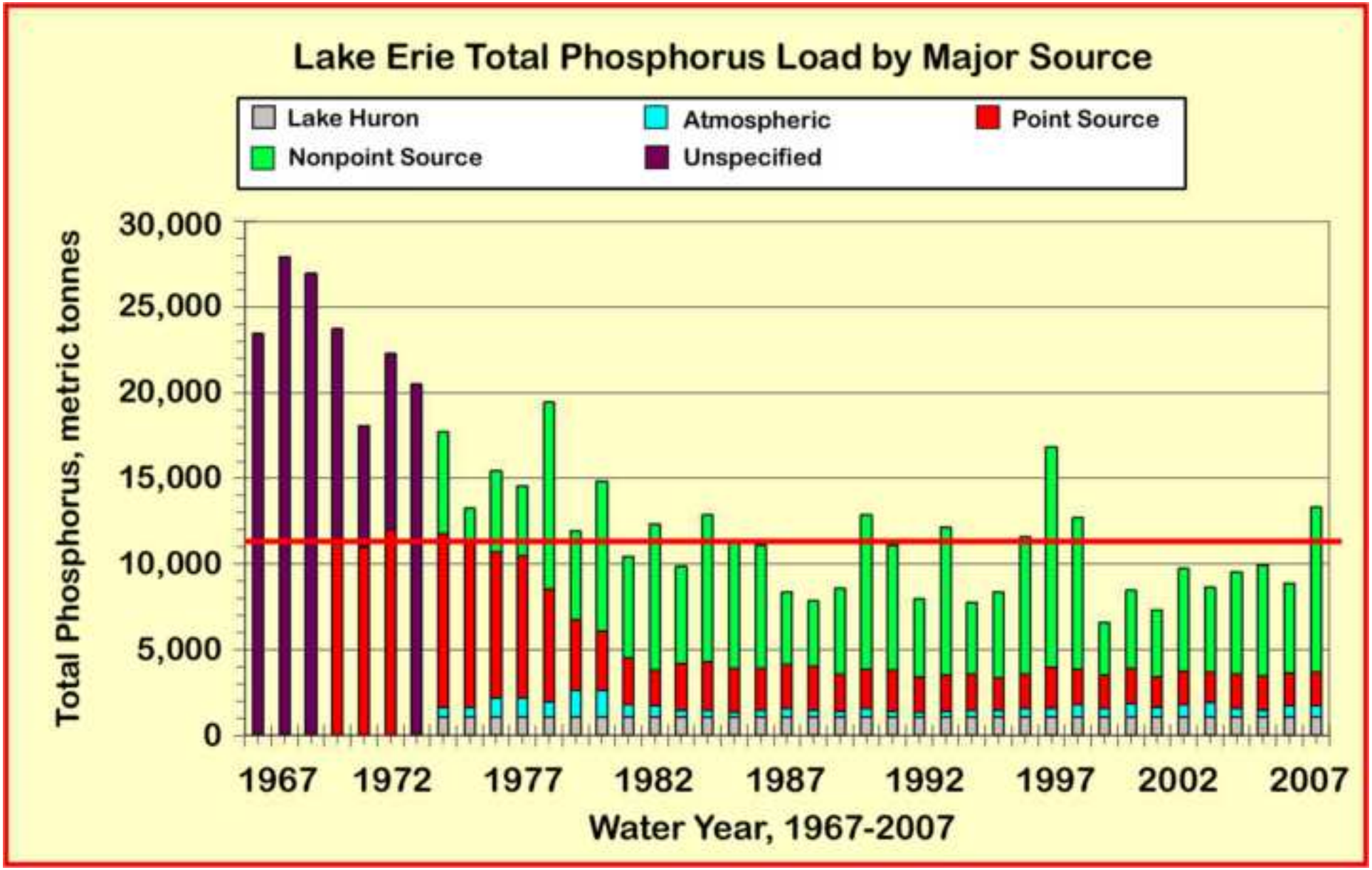

Figure 2

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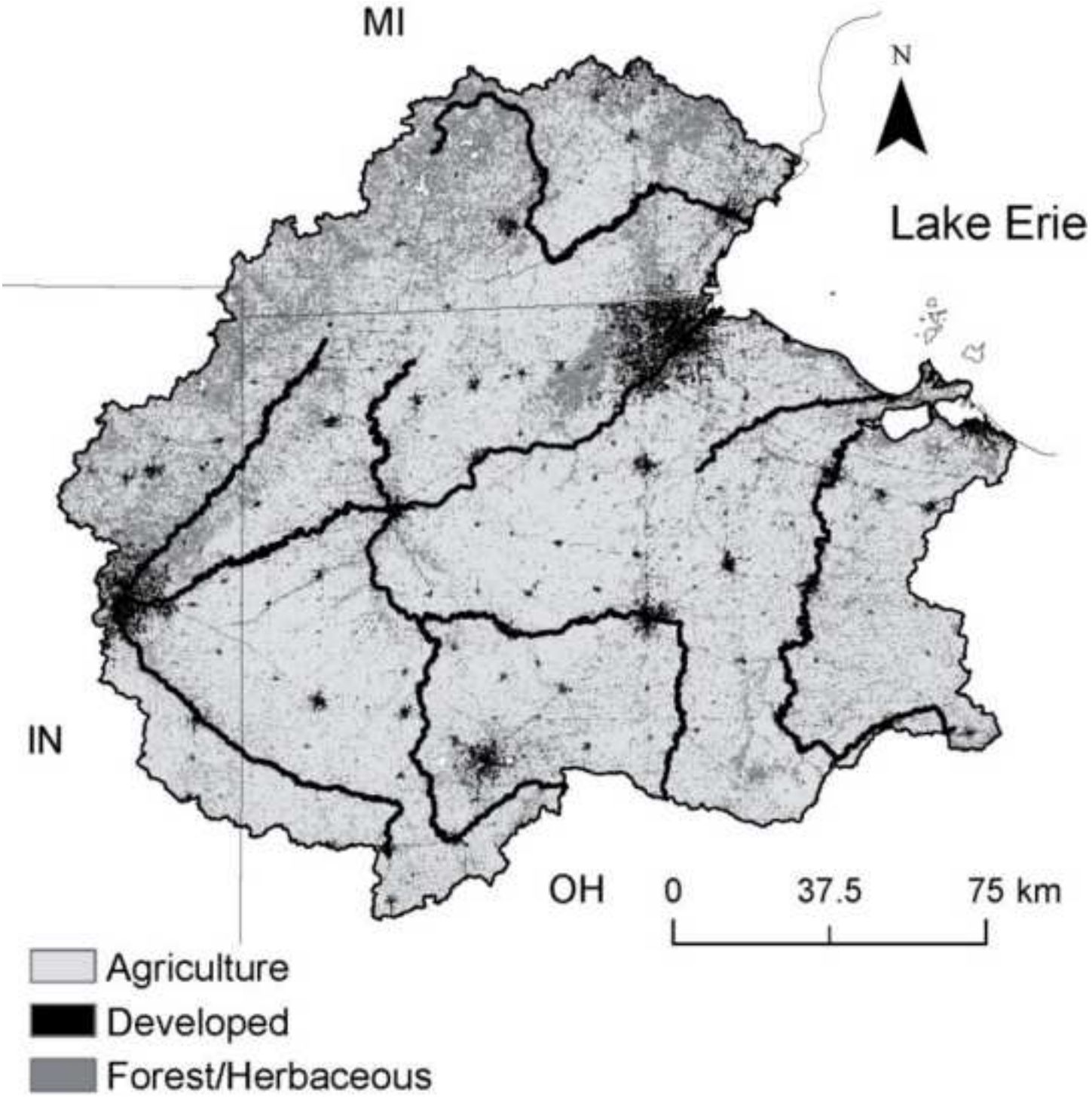

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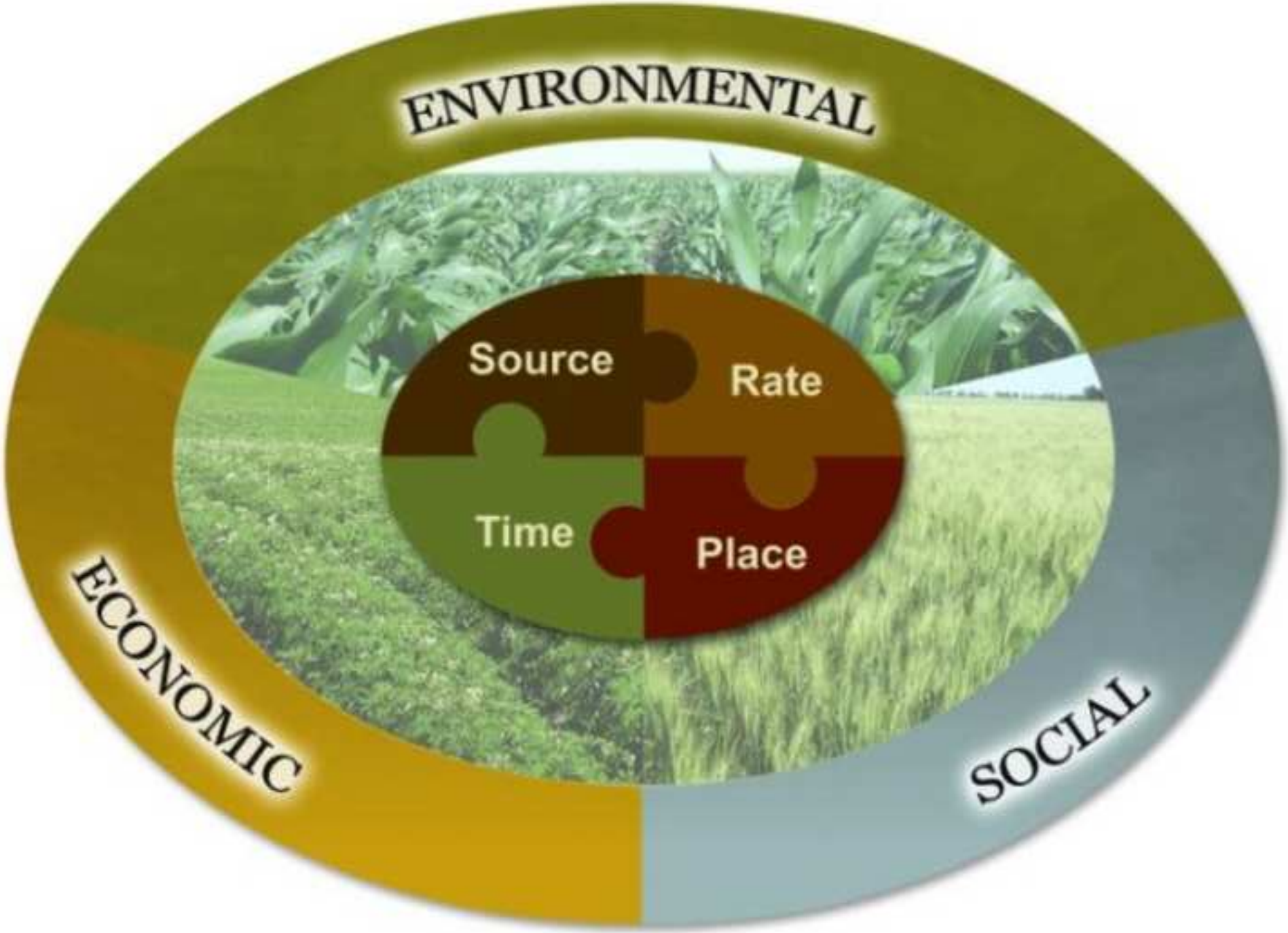

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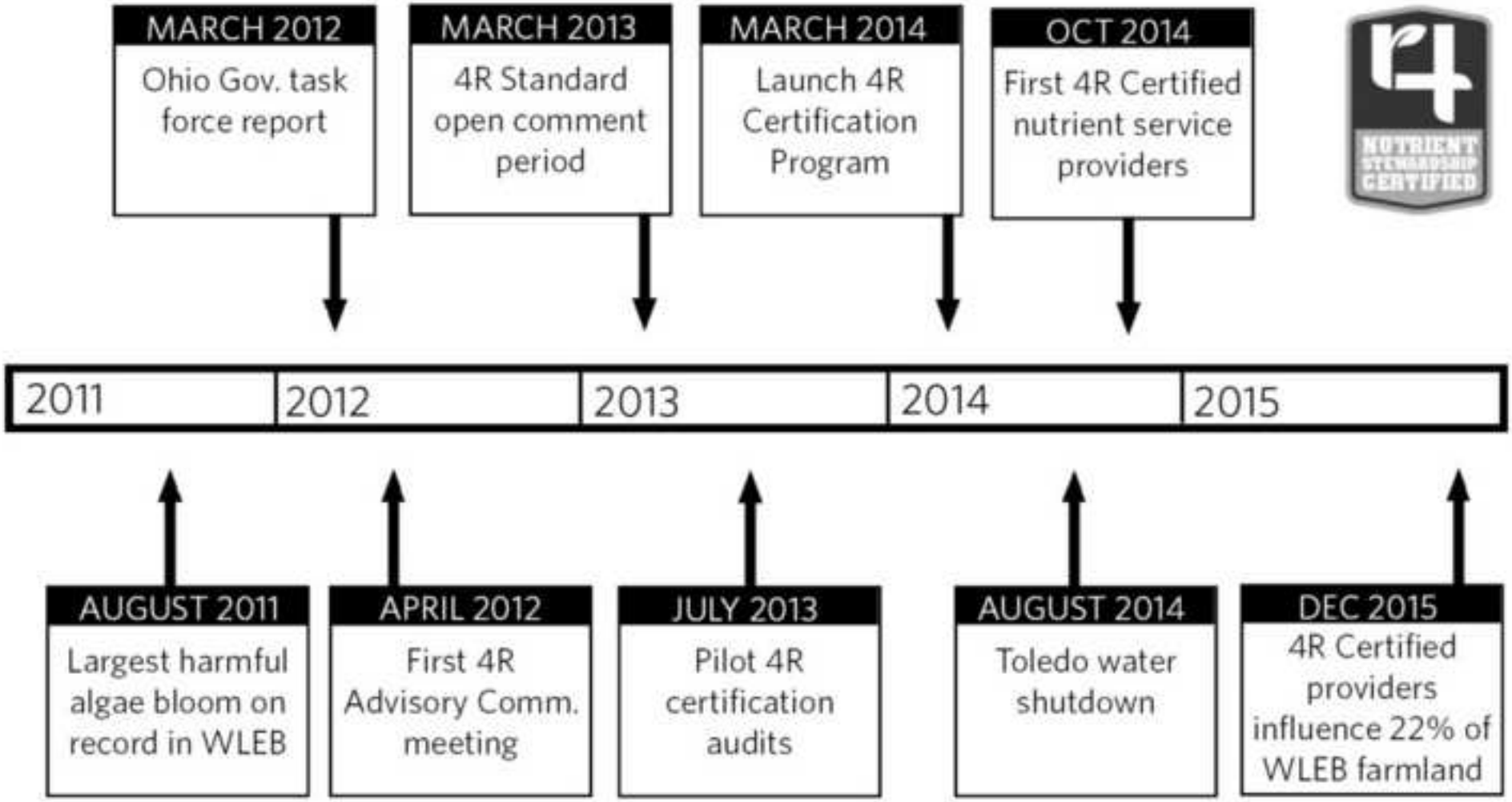

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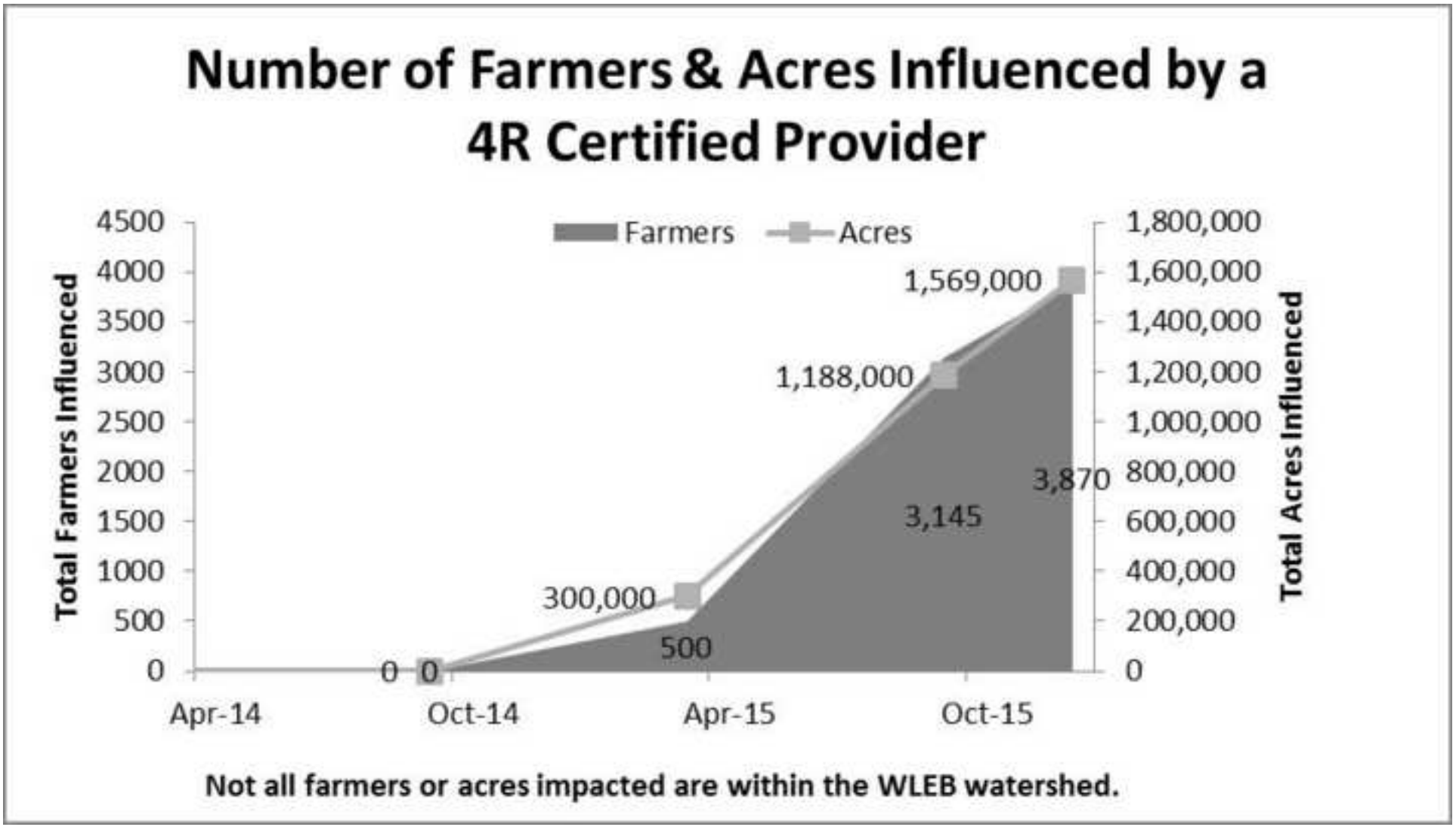

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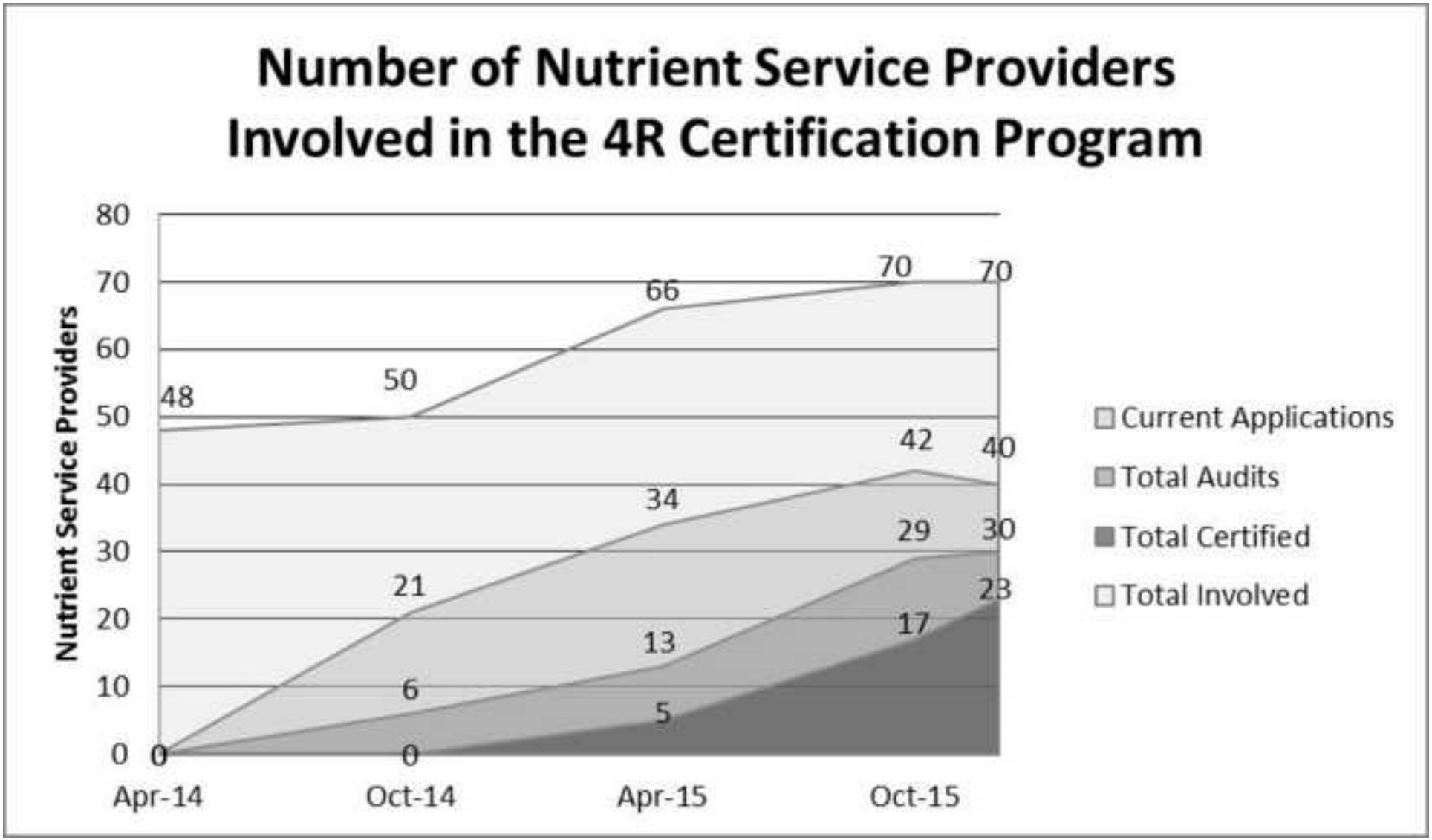

Appendix A

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Appendix B

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Appendix C

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