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## Informal Water Education and Public Outreach

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# Informal Water Education and Public Outreach

Natalie J. Carroll

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Readers of the *Journal of Contemporary Water Research and Education* are familiar with many soil and water quality and quantity threats and are working to mitigate problems and/or educate the public on how they can be involved in solutions. This issue focuses on informal educational efforts that target students, community members, youth, and others in venues outside the formal classroom. These efforts are especially important if we are to make progress with the challenges ahead of us.

The Cooperative Extension Service has provided educational publications and programs for the public for over 100 years. The Smith Lever Act formalized Extension in 1914, establishing USDA's partnership with land-grant universities to apply research and provide education in agriculture (NIFA 2015). Researchers at land-grant universities, particularly those in agriculture fields, generally have a good understanding of the importance of outreach and citizen engagement. However, researchers outside of agriculture or at non-land-grant universities may not realize the value of outreach and engagement. The National Science Foundation (NSF) recognizes the significance of sharing university knowledge and research with the public and recently took steps to assure that all researchers who receive NSF funding strive to share their knowledge and results with the public. Proposals are now evaluated on both the intellectual merit and broader impacts of the work, as noted:

> *The two merit review criteria are listed below. Both criteria are to be given full consideration during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. …*
>
> *When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:*
>
> - ***Intellectual Merit:*** *The Intellectual Merit criterion encompasses the potential to advance knowledge; and*
> - ***Broader Impacts:*** *The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.* (NSF 2014)

The "broader impacts" requirement has been a challenge for many researchers, as acknowledged by the NSF in a supporting document:

> *Proposals submitted to the National Science Foundation are evaluated through use of two merit review criteria, which all proposals must address explicitly. Experience shows that while most proposers have little difficulty responding to the criterion relating to intellectual merit, many proposers have difficulty understanding how to frame the broader impacts of the activities they propose to undertake.* (NSF 2001)

These concerns were more forcefully stated by the editorial in the APS article by Ernie Tretkoff,

*NSF's "Broader Impacts" Criterion Gets Mixed Reviews*:

> *However, some scientists object to research funding being coupled to education or outreach efforts. Mildred Dresselhaus of MIT says she has heard from many scientists who are unhappy with the broader impacts requirements, and who feel they should be funded based on the quality of their research, not for outreach. Many physicists feel they don't have the expertise to do outreach activities, she adds. She thinks education and outreach should be encouraged, but shouldn't be a requirement for research funding.*
>
> *Some scientists, especially those applying for their first grants, find the broader impacts requirement confusing and burdensome. Given the low success rate for scientists applying for their first grant, Dresselhaus says that these beginning professors are overstretched trying to survive. They feel they have to do everything possible to get a grant, and they think that they must devote significant time and energy to addressing the broader impacts criterion. Dresselhaus describes this situation as "punitive."* (Tretkoff 2015)

Tretkoff's article notes that "NSF grants that support large research centers often provide for extensive outreach projects" (and devote 10% of the funding to the center) which are of great benefit to research faculty. No mention is made, however, of the value of collaborating with faculty who have expertise in Extension, engagement, and outreach.

Researchers are advised to work with those experienced in Extension, outreach, engagement, and education to assure that they are sharing their new knowledge with the public. The project examples in this issue give an overview of how successful collaborations can work. These efforts should not be a last minute add-on to research efforts, however, but an integral part of the project and proposal development. The 10% of the proposal budget, mentioned by Tretkoff, should be a minimum for this collaboration, because doing good outreach and education takes time and money, just as any research does.

I hope that you enjoy reading the articles in this special issue and either find new ways to do outreach or see the value of collaborating with those who do this work.

The paper by Busse et al. describes a social indicator survey used to gather baseline data on urban and agricultural residents' attitudes towards, and usage of, water quality conservation practices. Local watershed organizations then used various outreach methods to encourage residents to implement specific practices. Post-project surveys were conducted to assess the effectiveness of outreach efforts. The authors found that while outreach efforts did not change attendee behavior, there were changes in participant attitudes. They also found that the primary barrier to practice adoption for all respondents was cost.

Co-authors Dann and Schroeder describe using camps as a context for nonformal learning. Their article describes a water resource education camp for youth that utilizes best practices in nonformal education methodologies. They used pre-camp and immediate post-camp surveys to evaluate their camp's effect on teens' Great Lakes literacy, place attachment, stewardship attitudes, and stewardship intentions. The authors include recommendations for designing nonformal water literacy education to enhance youth development and deep learning through nonformal camp-based programs.

Haynes and Cech describe multiple outreach efforts targeted at undergraduate students from multiple disciplinary areas and community members. The focus of the program is to teach the important role of water in Colorado's economy and environment and encourage residents' (students and community members) participation in finding solutions to local and statewide water issues.

The paper by Londo et al. describes the conditions that have led to the development of harmful algal blooms in Lake Erie, the legislative action that has been taken in attempts to curb the problem, and the educational programs developed by Extension, in partnership with state agencies, non-government organizations and other interested parties, to address water quality issues with Ohio agricultural producers and the general public.

The paper by Schneemann, Dorworth, and Gulley describes a collaborative outreach program, *Lawn to Lake*, targeted at people responsible for lawn and landscape care. The goal of this program is to reduce pesticide and fertilizer inputs to the Great Lakes

basin by promoting and implementing sustainable lawn and landscape practices (by promoting a switch from conventional lawn care practices to natural lawn care) at the community and household level. The authors also share "lessons learned" that will help others develop similar programs.

The article by Shelton et al. describes an effort, using Extension, classroom learning, and research, to develop educational programs addressing municipal stormwater runoff using green infrastructure and other best management practices. Extension programming targeted programs for design and green industry professionals, MS4 stormwater program managers, municipal officials, Master Gardeners, and homeowners. Classroom efforts included the development of new course lectures and design projects for undergraduates. Research studies evaluated rain garden hydrologic and plant growth attributes, homeowner perspectives on rain garden installation programs, and current regional bioretention design standards.

Authors Swistock et al. conducted research to document roadside spring use as a drinking water source and drinking water quality by surveying over 1,000 people and 37 springs for health-based drinking water quality. They also report on a more intensive follow-up study of ten of the 37 roadside springs. The authors found that frequent use of roadside springs with poor drinking water quality represent a significant health risk that needs to be addressed in public health education programs. The research also found that when only a single sample is collected, total coliform bacteria was found to be a better indicator than *Escherichia coli* bacteria of the overall microbiological drinking water safety of these springs.

Authors Wolfson et al. describe a collaborative education effort by four universities to deliver training programs that build capacity in local water resource professionals. Collaborators examined the core proficiencies that watershed group leaders need and evaluated how existing programs have approached professional training. They also analyzed effective methods for delivering the training. Results indicated that successful watershed leaders must be able to integrate basic natural science knowledge and a number of "soft" skills, including: leadership, communication, collaboration, technology, policy, and planning. The authors share the features of training programs that effectively build watershed leadership capacity.

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# Using Social Indicators to Evaluate the Effectiveness of Outreach in Two Indiana Watersheds

*Rebecca Busse[1], Jessica D. Ulrich-Schad[2], Lyn Crighton[3], Sara Peel[4], Ken Genskow[5], Linda Stalker Prokopy[1]

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**Abstract:** Nonpoint source pollution is recognized as one of the greatest threats to water quality in the United States. Outreach is one tool that can be used to help increase public awareness and motivate action towards addressing water issues. In order to create effective outreach, we must understand public perceptions of water quality, perceived barriers to implementing environmental solutions, and what types of outreach best connect with target audiences. In 2010, social indicator surveys were distributed in two watersheds in Indiana to gather baseline data on urban and agricultural residents' attitudes towards and usage of water quality conservation practices. Local watershed organizations then used various outreach methods to encourage residents to implement specific practices. In 2014, post-project surveys were conducted in both watersheds to assess whether the outreach efforts had been effective. Even with outreach efforts, many residents still were unaware that specific water pollutants were problems in their watershed. There were, however, positive changes in overall water quality attitudes. Changes in awareness and adoption of conservation practices varied by watershed and resident type, yet generally moved in a positive direction or were unchanged. The primary barrier to practice adoption for all respondents was cost. Outreach events were generally not well attended and did little to change attendee behavior. Some outreach activities seem to be more useful than others in terms of self-reported effectiveness while others are clearly visible to the community and may be a helpful way to raise awareness.

**Keywords:** *nonpoint source pollution, water quality, conservation behaviors, limiting factors, education, pre/post surveys*

Nonpoint source (NPS) pollution is recognized as one of the greatest threats to water quality in the U.S. (USEPA n.d.; USEPA 2013). Excess nutrients in lakes and rivers lead to an abundance of aquatic plants and algae which can produce toxic cyanobacteria and also deplete water of oxygen during decay, creating hypoxic zones in both freshwater and marine systems (e.g., USEPA 2013). There are many sources of NPS pollution, including agricultural practices, urban runoff, septic systems, and recreational activities. While some headway has been made in addressing NPS pollution, more outreach could be done to increase urban and rural residents' awareness of water quality issues and encourage increased adoption of conservation best management practices (BMPs). Common agricultural BMPs include planting cover crops, providing riparian buffers, and installing grassed waterways. Common BMPs in lakeshore and riparian areas emphasize maintaining natural shoreline, and reducing potential for direct nutrient runoff to water. Common urban BMPs include rain gardens, rain barrels, and pervious pavement.

Resource managers and educators design and present outreach based on their understanding of the audience's perceptions of water quality, their perceived barriers to implementing environmental solutions, and what type of outreach best reaches that target audience (Floress et al. 2015; McKenzie-Mohr and Smith 1999). Resource managers seeking to reduce NPS pollution provide

technical support to landowners (e.g., help with conservation planning or training in agricultural nutrient management), financial assistance for adopting and maintaining BMPs, and a variety of outreach activities including informational materials, demonstrations, on-site visits, and other educational events. Social indicator surveys focused on understanding underlying attitudes, perceptions, and awareness for specific areas can help determine important barriers and opportunities, and identify means to address them (Prokopy et al. 2009; Genskow and Prokopy 2011; Prokopy and Genskow 2015). This paper examines conservation behaviors and perceptions of water quality among residents of the Upper Tippecanoe and Region of the Great Bend of the Wabash River watersheds in Indiana. Using social indicator surveys conducted in 2010 and 2014 with residents and agricultural producers in both watersheds, we examine how perceptions of water quality have changed over time, if usage of conservation practices has increased, and what barriers exist for adoption of conservation practices. Comparing pre and post project responses helps determine if outreach has been effective in changing attitudes and practices related to water quality. These findings can be used to help conservation practitioners understand and design more effective outreach programs, a task which plays a key role in the conservation of aquatic resources (Bjorkland and Pringle 2001; Dietz and Stern 2002).

## Literature Review

Outreach and extension activities seeking to change environmental behaviors are predicated on foundational theories and conceptual models about behavior, values, and individual perceptions. Notably the Theory of Planned Behavior (Ajzen 1991, 2002), the Value-Belief-Norms Theory (Stern 2000), the Diffusion of Innovations Theory, and the Stages of Change (Prochaska et al. 1992; Rogers 1995) suggest that decisions about whether or not to adopt a BMP depend on the interplay of factors such as skills, knowledge, values, beliefs, and behaviors of individuals considering the change.

Numerous studies have identified and reinforced the importance of understanding these factors, or social indicators. Common barriers to adoption of practices include differences in demographics and levels of awareness among audiences (Bjorkland and Pringle 2001), attitudes towards local environmental issues (Stough-Hunter et al. 2014), social norms/approval of one's neighbors (Ajzen 1991; Fishbein and Ajzen 2010), cost of implementing (Lorenzoni et al. 2007; McKenzie-Mohr and Smith 1999), and perceived ability to implement a practice (Ajzen 1991; Ajzen 2002; Fishbein and Ajzen 2010). Other barriers include not wanting to change one's regular practices, fear of sacrificing one's standard of living, belief that one's actions cannot affect the environment, and fear that the government will not take responsibility for environmental issues or that other people will become free riders (Lorenzoni et al. 2007).

While research has documented demographic characteristics associated with pro-environmental behavior, common barriers to adopting conservation practices, and generally effective outreach strategies, there is a shortage of published research focused on the effectiveness of different outreach approaches in influencing attitudes and behaviors towards specific water quality BMPs among targeted populations. Understanding social indicators can help educators plan, evaluate, and improve outreach programs (Behn 2003; Moynihan 2005). In their review for voluntary NPS programs, Genskow and Wood (2009) noted that while metrics can be misleading, intermediate indicators that follow a theory of change can be particularly useful for evaluating efforts to bring about voluntary adoption of conservation behaviors.

The social indicators framework used in this paper (Genskow and Prokopy 2011) reflects substantial literature on factors influencing the adoption of conservation practices in agricultural settings (e.g., Nowak 1992; Lambert et al. 2007; Prokopy et al. 2008), riparian/lakeshore settings (e.g., Amato et al. 2015; Shaw et al. 2011), and urban areas (Brehm et al. 2013). The context in which NPS outreach activities are conducted is critical for interpreting and acting upon evaluative information (Stough-Hunter et al. 2014; Thurston et al. 2012). For any study reviewing pre and post data, it is important to acknowledge the role of other influences on attitude or behavior changes

beyond program interventions and the uncertainties involved in any data collection efforts.

In this paper we use social indicator surveys to 1) examine whether general conservation attitudes and behaviors change at the watershed level and among specific types of residents (e.g., agricultural producers and urban/lake residents) with the introduction of various outreach strategies, 2) provide a better understanding of the barriers that different populations perceive to implementing water quality BMPs in order to advise local watershed groups on how to create more effective outreach in the future, and 3) determine which outreach methods are the most effective at reaching targeted audiences.

## Methods

### Study Watersheds and Outreach

The Upper Tippecanoe River Watershed in northeastern Indiana covers 114 square miles including portions of Whitley, Noble, and Kosciusko counties (see Figure 1) (TWF 2013). A 2010 census documented the population of this watershed as 11,860 residents (obtained from the TWF director). Although seventy-five percent of the land use is agricultural, the watershed contains over 50 lakes and is the headwaters of the Tippecanoe River. It connects with the Ohio and Mississippi rivers, and eventually drains into the Gulf of Mexico. The Tippecanoe Watershed Foundation (TWF) is a nonprofit organization operating in the watershed that was founded in 1997 with the mission of protecting and improving water quality in local lakes and streams. Many of the waterbodies in the watershed are impaired by phosphorus and *Escherichia coli* and the Tippecanoe River is impaired by *E. coli*, dissolved oxygen, and nutrients. Pollution sources of concern include manure management, lawn care, streambank and shoreline practices, and failing septic systems (Crighton 2015).

Outreach efforts conducted by the TWF from 2010 to 2014 included distributing materials and organizing events. The primary outreach method TWF used to target urban/lake residents included the Clear Choices Clean Water Campaign, which involved distribution of postcards, posters,

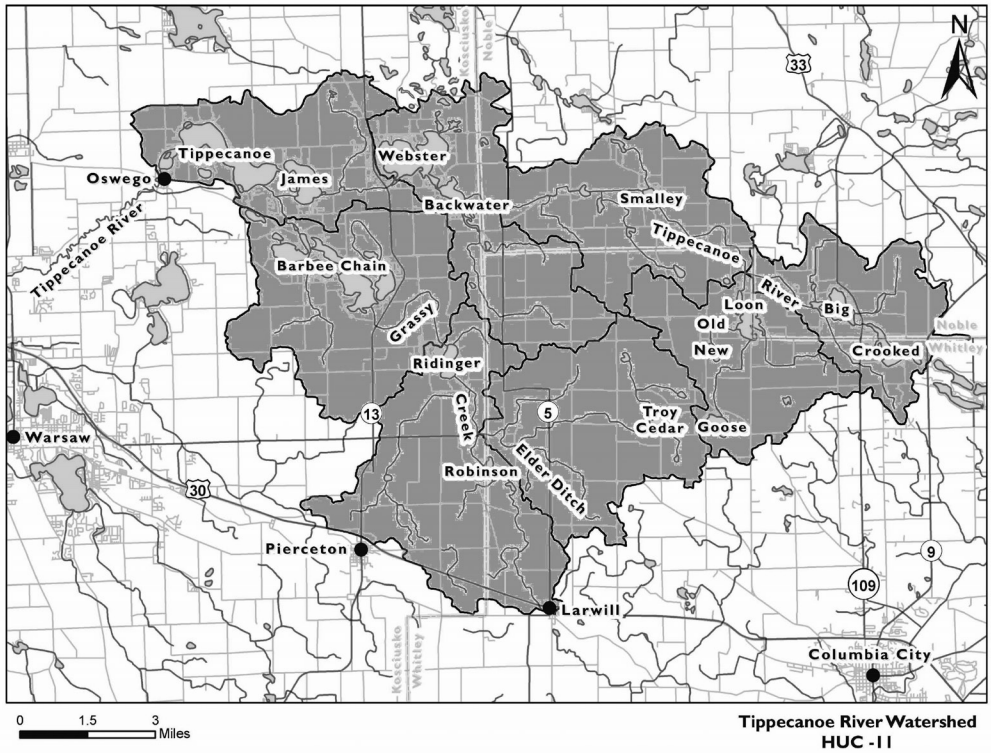


**Figure 1.** Map of the Upper Tippecanoe River Watershed, IN (shaded area).

newsletter ads, and Facebook posts that encouraged residents to take a pledge online to commit to target conservation practices. The campaign was also promoted at community meetings and events. Additionally, TWF developed the Healthy Shorelines Initiative, which included workshops co-hosted by local lake associations. During the workshops, an expert explained the benefits of natural lake shores, as well as their cost and the process of implementation. Lake residents who installed healthier shorelines with native plants and/or glacial stones received signs to place along their shorelines during the boating season. TWF also mailed a newsletter 2-3 times per year which informed lake residents of water quality issues, as well as events happening in the watershed. Representatives from TWF attended monthly local lake association meetings to distribute flyers for events. Finally, TWF helped start the Northern Indiana Lakes Festival, which educates people about water resources and showcases lake-related events in Kosciusko County with booths, vendors, and a business expo.

TWF sponsored several other outreach efforts with the needs of agricultural producers in mind. The primary agricultural outreach method was the hiring of two local watershed conservationists to talk directly with farmers about conservation practices and to assist them in implementation of BMPs. They also shared details about cost-share programs available through TWF and partner agencies, including Natural Resources Conservation Service (NRCS), Soil and Water Conservation Districts (SWCD), Indiana Department of Environmental Management (IDEM), and Indiana Department of Natural Resources Lake and River Enhancement Program (IDNR LARE). Other outreach methods included sponsoring indoor pasture walks and a cover crop field day, where TWF enlisted a local farmer and SWCD board member to speak about his experience with cover crops and give a tour of his farm. TWF also partnered with a local farm sales company to hold a Soil Health Workshop at the company's customer appreciation event. Finally, Healthy Soils Clean Water signs were installed in agricultural producers' fields along roadways to highlight those who participated in no-till planting, cover crops, and nutrient management.

The second study area is the Region of the Great Bend of the Wabash (referred to as Wabash Watershed for the remainder of this paper). This watershed covers 478 square miles including portions of Benton, White, Fountain, Montgomery, Tippecanoe, and Warren counties and is primarily agricultural although the majority of the cities of Lafayette and West Lafayette are located within its boundaries (see Figure 2). The Watershed Management Plan for the Wabash documented 107,448 residents in 2011 (WREC 2011). There was an average of 3,270 people/mile$^2$ at the time the plan was created (WREC 2011). The organization working in this watershed is the Wabash River Enhancement Corporation (WREC), established in 2004. Their mission is to improve environmental and economic conditions in the Greater Lafayette Region and the Wabash River Corridor in a sustainable manner. *E. coli*, sediment, nutrients, and poor quality (low density/low diversity) biotic communities (fish and macroinvertebrate populations) are known impairments in the Wabash (Peel 2011). Historical water sampling data indicate that nitrogen, phosphorous, *E. coli*, and suspended solids are an issue throughout the watershed (Peel 2011). There are fish consumption advisories on the Wabash and fish populations are declining (Pyron et al. 2006). There are also problems with erosion, livestock having access to streams, and a lack of adequate buffering between streams and agricultural and urban land (Peel 2011).

Many of WREC's events targeted both urban and rural agricultural residents to educate landowners about BMPs and implementation opportunities, connect the community to the Wabash River, and provide conservation education for youth and adults. Education efforts included two Paint the Rain events to raise awareness about protecting the Wabash through using rain barrels to collect and retain stormwater. Additionally, WREC partnered with other local organizations each year to host an educational booth at the Tippecanoe County Fair. The Wabash Riverfest, organized annually by WREC, aims to teach community members about the importance of the Wabash with games, activities, and educational booths and connect the community with the Wabash. The Wabash Sampling Blitz, organized semi-annually, engages community members with sampling water quality.

WREC also organized a number of rain garden seminars and workshops focused on providing participants with the necessary skills to design and install rain gardens and opportunities to view how they fit within the landscaping efforts of other gardeners. Annual green tours highlighting residents' homes incorporating green practices were also part of their efforts. Finally, WREC continues to promote Detrash the Wabash each year, an event that encourages community members to clean up the Wabash River to promote water quality.

Outreach events that specifically targeted urban residents included: pervious concrete demonstration installation; workshops for gardeners and local residents which highlighted rain barrel installation; native plant workshop series that focused on plant selection, site selection, and maintenance of native plants; a green tour where community members were taken to local residences to speak with homeowners about the water quality practices that they have adopted; and educational presentations as part of the local master naturalist training. WREC also created and distributed Eco Champion signs to local residents who installed a rain barrel, rain garden, native plants, or pervious pavement. If they had implemented multiple water quality practices, they could add a sticker to their sign for each practice.

The outreach that WREC developed specifically for agricultural producers included a variety of field days. These field days were typically sponsored and promoted with Tippecanoe County SWCD and gave producers a chance to learn more about practices by seeing them on site. WREC also promoted the Cover Crop Breakfast at which producers learned about cover crops and soil health, and a Soil Health Workshop that enabled landowners to listen to national level speakers talk about soil health. Finally, they also co-sponsored the Indiana Cover Crop Forum where landowners listened to national level speakers explain the benefits and management of cover crops.

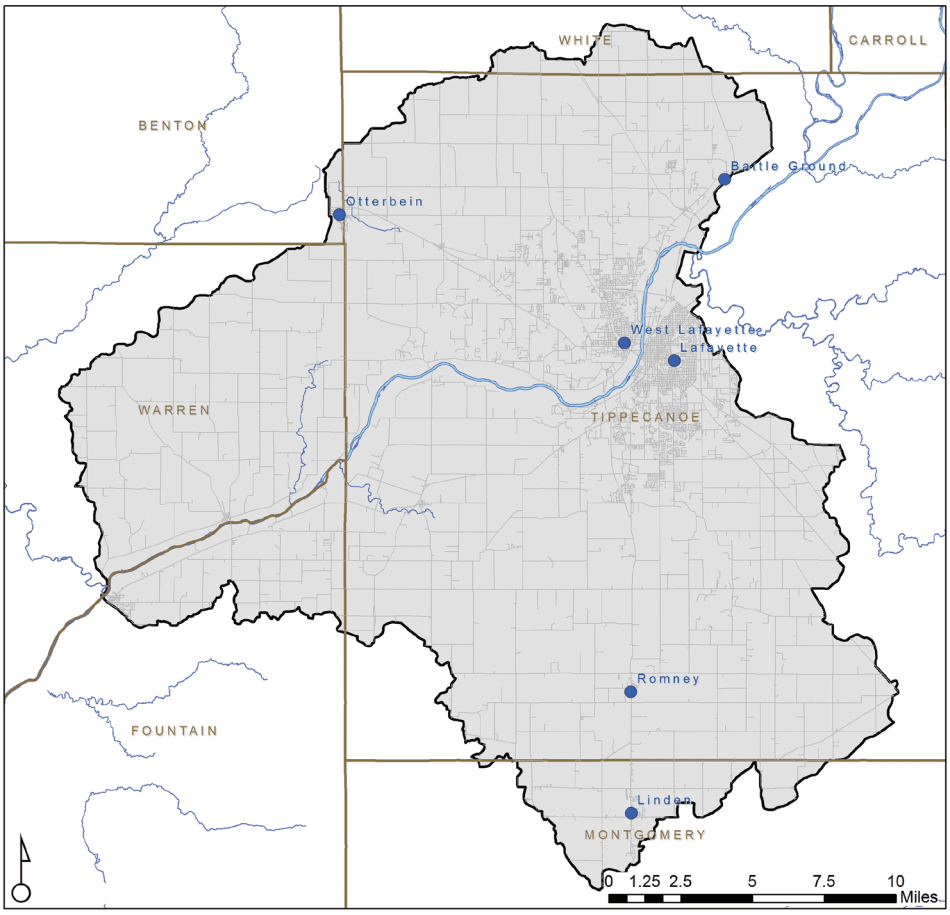


**Figure 2.** Map of the Great Bend of the Wabash River Watershed, IN (shaded area).

**Pre and Post Social Indicator Surveys**

The data used in this paper are from four pre/post social indicator surveys, consistent with Genskow and Prokopy (2011), conducted in the study watersheds in both 2010 and 2014 (see Table 1). In the Upper Tippecanoe Watershed, pre/post surveys were conducted with agricultural producers and urban/lake (in some places we refer to this as an "urban" survey for easier comparisons with the Wabash Watershed) residents. In the Wabash Watershed, agricultural producers and urban residents were surveyed. Each survey included questions about perceptions of water quality, background of the respondents and their property, and their usage of and attitudes toward conservation practices. There were also questions specific to each resident type. For instance, agricultural producers were asked conservation questions related to their farming practices, while urban/lake residents were asked about their lake or city property. The local partner watershed organizations were interested in different conservation practices, so the specific practices inquired about for each resident type differed in each watershed. In order to evaluate the outreach conducted between 2010 and 2014, the post surveys (2014) included questions about outreach effectiveness relevant to each watershed and resident group.

The sampling frames were generated differently for each survey. For the surveys of agricultural producers, a Freedom of Information Act (FOIA) request was made to the Farm Service Agency requesting the names and addresses of all owners or renters of farmland in the study counties who had received Farm Service Agency (FSA) payments in 2009. All farmers on these lists were sent surveys. The same address lists were used in 2010 and 2014, meaning that some farmers took the survey both years. The urban/lake resident survey in the Upper Tippecanoe Watershed was sent to residents on TWF's mailing list of all lake residents, which was updated in 2014. A computer-generated simple random sample was taken from the sampling frame in both 2010 (n=879) and 2014 (n=901). The survey of urban residents in the Wabash Watershed was mailed to a computer-generated simple random sample (n=1097 in 2010; n=1100 in 2014) of those on address lists purchased from Survey Sampling International. A different list, the Census tracts that contain the cities of Lafayette and West Lafayette, was purchased for the pre and post surveys using the same parameters.

For each survey, our sample was contacted up to five times which achieved an overall response rate of 41%, with variation from 27% to 54% by survey (see Table 1; response rates were calculated by taking out incorrect addresses or duplicates). Using a modified version of the Dillman (2000) Tailored Design Method, potential respondents were first sent an advance letter, which informed them that the survey would be mailed to them shortly and included the option to take the survey

**Table 1.** Social indicator surveys in two Indiana watersheds.

| Survey watershed | Type of resident | Year | N | Response rate (%) | Sampling frame |
|---|---|---|---|---|---|
| Upper Tippecanoe | Agricultural producer | 2010 | 125 | 54 | Freedom of Information Act (FOIA) request |
| | | 2014 | 107 | 50 | FOIA request (same list as 2010) |
| | Urban/lake | 2010 | 376 | 48 | Tippecanoe Watershed Foundation (TWF) list of residents |
| | | 2014 | 351 | 42 | TWF list of residents (updated) |
| Wabash | Agricultural producer | 2010 | 341 | 51 | FOIA request |
| | | 2014 | 235 | 39 | FOIA request (same list as 2010) |
| | Urban | 2010 | 373 | 38 | Sample purchased from Survey Sampling International (SSI) |
| | | 2014 | 278 | 27 | Sample purchased from SSI (new) |
| Total | | | 2,186 | 41 | |

online. We then mailed those who had not yet taken the survey online a paper copy of the survey along with a stamped and addressed return envelope. At about two week intervals, non-respondents were then sent a reminder postcard, then a second copy of the survey, and finally, if no response, a third copy of the survey with a reminder postcard.

### Social Indicators

We used social indicators from the surveys to examine five areas of interest: views on water quality impairments, attitudes toward water quality, perceptions of barriers to the adoption of water quality BMPs, awareness and usage of conservation practices, and the effectiveness of watershed level outreach. Survey respondents were asked in both 2010 and 2014 whether they thought five water quality impairments (nitrogen, phosphorus, sedimentation, bacteria, and algae) were a problem in their area. The answer options were: not a problem, slight problem, moderate problem, severe problem, or don't know. The variables were recoded to indicate whether the respondents saw each impairment as a problem (1=slight, moderate or severe) or not (0=not a problem or didn't know). Ten questions asking the degree to which respondents agreed with statements about water quality were included on the surveys in 2010 and 2014 (e.g., "I would be willing to pay more to improve water quality."). The variables were recoded to indicate agreement (1=strongly agree and agree) or disagreement/neutrality (0=strongly disagree, disagree, neither disagree nor agree). In each of the pre/post surveys, respondents were asked whether a number of factors limited their ability to use conservation practices in general, with response choices being a lot, some, a little, not at all, or do not know. We compared those who said a factor limited them a lot (1=a lot) to all other responses (0=some, a little, not at all, don't know).

Each of the four pre/post surveys also inquired about residents' awareness and usage of different conservation practices. For each practice, survey respondents indicated one of the following: never heard of the practice; somewhat familiar with the practice; knew how to do the practice, but weren't using it; or currently using it. We recoded this question to examine changes in use (1=currently using; 0=not aware of or using) and awareness (1=somewhat familiar, familiar, using; 0=never heard of) in each of the four pre/post surveys. Lastly, both urban and agricultural survey respondents in 2014 were asked a series of questions pertaining to outreach conducted in their watershed and targeting their specific community. Respondents were asked about their familiarity with their local watershed organizations (1=familiar; 0=not familiar), attendance at outreach events (1=attended at least one event; 0=did not attend any events), perceptions of event effectiveness from attendees (1=saw at least one event they attended as very or somewhat effective; 0=did not see any event they attended as effective), and changes in reported behavior as a result of attendance at an outreach event (1=adopted conservation practice; 0=did not adopt).

### Data Analysis

We pooled the data from the four pre surveys conducted in 2010 and the four post surveys conducted in 2014 to examine whether views of local water quality impairments, attitudes towards water quality, and perceived limitations had changed over time. To test whether there were significant changes in all respondents' attitudes from 2010 to 2014, we used two-sample t-tests, which test if two population means are equal (Hamilton 2009). We used the same statistical test to determine whether there were significant changes from 2010 to 2014 in each of the four individual pre-post surveys and between agricultural producers and urban/lake residents in 2014. Because local efforts focused on different conservation practices in each survey, we used two-sample t-tests to examine whether there were significant changes in awareness and usage of specific conservation practices in each of the four pre-post surveys only (e.g., we did not pool the data by year). Finally, to examine the impact of outreach, we looked for significant differences between each pairing of the four post surveys by using a one-way analysis of variance (ANOVA) and a Scheffe multiple-comparison test.

## Results

### Demographic Profile of Survey Respondents

The majority of survey respondents in 2010 and 2014 were male (see Table 2). Agricultural producer survey respondents were more likely to be male,

which is reflective of the farming population in general. The average age of survey respondents was 63.7 years in 2010 and 64.1 years in 2014. Nearly one-half of survey respondents had earned a four year college degree or higher in both 2010 and 2014 (44.5% and 47.7%, respectively). The urban/lake residents were more likely to have a college education than the agricultural producers (Table 2). Agricultural producers in the Upper Tippecanoe Watershed had on average 339.2 acres, while those in the Wabash watershed were slightly larger on average with 461.5 acres.

### Views of Water Quality Impairments

When examining the pooled responses from all surveys, no significant changes in views of water quality impairments were found from 2010 to 2014 (see Table 3). In both survey years, residents were most concerned about sedimentation and least concerned about nitrogen. There were also few significant changes in perceptions of water quality impairments from 2010 to 2014 when examining the four pre-post surveys individually. Only the survey of agricultural producers in the Wabash Watershed indicated any significant change in beliefs over time; respondents were significantly less likely to see bacteria and sedimentation as problems in their area in 2014 than in 2010. In combined watersheds in 2014, agricultural producers were significantly more likely than urban/lake residents to see nitrogen, phosphorus, and bacteria as problems, while urban/lake residents were more likely than agricultural producers to see algae as a problem.

### Attitudes toward Water Quality

In the pooled dataset, there were a number of significant changes in attitudes towards water quality from 2010 to 2014, all in the direction one would expect with increased watershed-level outreach (see Table 4). In both 2010 and 2014, respondents were the most likely to agree with the statement that it is their own personal responsibility to help protect water quality, but the least likely to agree with the statement that they are willing to pay more to improve water quality, though there was a significant increase in willingness to pay between 2010 and 2014. There were no significant changes in water quality attitudes in both Upper Tippecanoe Watershed surveys, while changes in attitudes towards water quality among Wabash survey respondents were much more pronounced. Wabash agricultural producers were significantly more likely to say that the economic stability of their community depends on good water quality, that their actions have an impact on water quality, and that the quality of life in their community depends on good water quality. Wabash urban residents were significantly more likely to agree with six out of ten statements, all of which moved in the direction of more positive views towards

**Table 2.** Demographic profile of survey respondents.

| | Sex (% female) | Age (mean years) | Education (% with 4 year college degree or higher) | Acres owned (mean) |
|---|---|---|---|---|
| All (2010) | 25.4 | 63.7 | 44.5 | N/A* |
| All (2014) | 28.3 | 64.1 | 47.7 | N/A |
| Upper Tippecanoe, ag. (2014) | 11.4 | N/A | 30.1 | 339.2 |
| Upper Tippecanoe, urban/lake (2014) | 32.1 | 65.6 | 49.6 | N/A |
| Wabash, ag. (2014) | 16.9 | 65.9 | 39.1 | 461.5 |
| Wabash, urban (2014) | 34.6 | 60.2 | 53.4 | N/A |

*N/A indicates that a similar question was not asked on the survey.

**Table 3.** Percentage of survey respondents who saw impairments as problems. Circles indicate significant differences over time (non-shaded rows) or between resident type (shaded rows) at *p<0.05, **p<0.01, or ***p<0.001.

| Survey Respondents | Nitrogen | Phosphorus | Sedimentation | Bacteria | Algae |
|---|---|---|---|---|---|
| All (2010) | 41.9 | 43.0 | 69.5 | 51.2 | 65.9 |
| All (2014) | 44.9 | 45.4 | 68.6 | 47.9 | 66.4 |
| Upper Tippecanoe, ag. (2010) | 57.0 | 54.6 | 56.4 | 55.6 | 57.3 |
| Upper Tippecanoe, ag. (2014) | 43.0 | 45.4 | 43.6 | 44.4 | 42.6 |
| Upper Tippecanoe, urban/lake (2010) | 47.9 | 49.8 | 50.6 | 51.3 | 52.0 |
| Upper Tippecanoe, urban/lake (2014) | 52.1 | 50.2 | 49.4 | 48.7 | 48.0 |
| Wabash, ag. (2010) | 57.9 | 59.4 | **62.7** | **63.3** | 60.4 |
| Wabash, ag. (2014) | 42.1 | 40.6 | **37.3*** | **36.7*** | 39.6 |
| Wabash, urban (2010) | 56.0 | 55.9 | 58.5 | 59.8 | 58.1 |
| Wabash, urban (2014) | 44.0 | 44.1 | 41.5 | 40.2 | 41.9 |
| All ag. (2014) | **54.7** | **52.3** | 68.5 | **53.9** | **59.2** |
| All urban/lake (2014) | **39.8***** | **41.7**** | 68.6 | **44.8*** | **70.1**** |

Notes: Significance calculated using two sample t-tests. "ag." indicates agricultural producers.

water quality. In combined watersheds in 2014, urban/lake residents indicated significantly more agreement with many statements that exhibit more positive attitudes towards water quality than agricultural producers; of note, urban/lake residents were much more likely than agricultural producers to be willing to pay more to improve water quality (51% versus 25%, respectively).

### Perceptions of Barriers

There were no significant changes in perceptions of each limiting factor from 2010 to 2014 in the pooled survey responses or the four pre/post surveys (see Table 5). In 2014, survey respondents were most concerned about the personal costs associated with adopting conservation practices. Nearly one out of every three (31.4%) respondents saw expenses as a barrier that limited their usage of conservation practices a lot. Many also saw a lack of access to equipment as a significant barrier to implementing a practice. On the other hand, not knowing anyone else using the practice and approval of neighbors were the least limiting factors. Urban residents were significantly more likely to say that the lack of information about a practice, not knowing anyone implementing the practice, and not being able to see a demonstration limited their ability to adopt a conservation practice a lot than were agricultural residents.

### Awareness and Usage of Conservation Practices

Between 2010 and 2014, agricultural producers in the Upper Tippecanoe Watershed became significantly more aware of approved grazing management plans and more likely to have adopted the practice (see Table 6). Awareness and usage of comprehensive nutrient management plans also increased, but not significantly. There was little change in residents' awareness and usage of the other practices. There were no significant changes between 2010 and 2014 in the awareness or usage of the three conservation practices inquired about among agricultural producers in the Wabash Watershed. Awareness and usage of conservation practices was generally lower, although not by a significant amount. Urban/lake residents of the Upper Tippecanoe Watershed were significantly more likely to have heard of and use vegetation

**Table 4.** Percentage of survey respondents who agreed with statements about water quality. Circles indicate significant differences over time (non-shaded rows) or between resident type (shaded rows) at *p<0.05, **p<0.01, or ***p<0.001.

| Survey Respondents | I would be willing to pay more to improve water quality. | Taking action to improve water quality is not too expensive for me. | It is important to protect water quality even if it costs me more. | What I do on my land makes a difference in overall water quality. | It is important to protect water quality even if it slows economic development. | The quality of life in my community depends on good water quality. | My actions have an impact on water quality. | It is not okay to reduce water quality to promote economic development. | The economic stability of my community depends on good water quality. | It is my personal responsibility to help protect water quality. |
|---|---|---|---|---|---|---|---|---|---|---|
| All (2010) | **35.9** | 42.6 | **54.4** | 72.4 | 74.9 | **75.8** | 82.1 | **80.4** | **75.0** | 90.7 |
| All (2014) | **41.9**** | 45.2 | **60.1*** | 75.4 | 76.8 | **81.3**** | 83.5 | **84.0*** | **84.7***** | 90.5 |
| Upper Tippecanoe, ag. (2010) | 20.2 | 36.4 | 47.2 | 75.0 | 71.3 | 72.4 | 87.0 | 73.0 | 76.2 | 92.7 |
| Upper Tippecanoe, ag. (2014) | 22.7 | 34.0 | 45.4 | 70.5 | 67.4 | 71.4 | 82.5 | 76.3 | 81.4 | 88.8 |
| Upper Tippecanoe, urban/lake (2010) | 44.4 | 48.2 | 58.5 | 78.0 | 79.8 | 86.2 | 87.7 | 86.2 | 83.4 | 94.1 |
| Upper Tippecanoe, urban/lake (2014) | 47.0 | 55.3 | 63.1 | 81.1 | 77.5 | 85.1 | 86.8 | 88.3 | 82.0 | 93.1 |
| Wabash, ag. (2010) | 20.7 | 36.6 | 51.8 | 69.2 | 73.5 | **63.8** | **77.0** | 81.4 | **71.0** | 89.6 |
| Wabash, ag. (2014) | 26.6 | 43.4 | 54.5 | 72.3 | 72.5 | **75.4**** | **84.0*** | 80.3 | **88.3***** | 89.3 |
| Wabash, urban (2010) | **45.9** | 44.2 | **55.0** | 68.7 | **72.4** | **76.9** | 79.1 | **76.3** | **69.8** | 87.5 |
| Wabash, urban (2014) | **55.3*** | 37.9 | **66.7**** | 72.3 | **83.1**** | **85.0*** | 79.0 | **84.2*** | **86.3***** | 88.9 |
| All ag. (2014) | **25.4** | **40.5** | **51.6** | 71.8 | **70.9** | **74.1** | 83.6 | **79.0** | 86.2 | 89.1 |
| All urban/lake (2014) | **50.6***** | **47.8*** | **64.6***** | 77.3 | **79.9**** | **85.1***** | 83.5 | **86.5**** | 83.9 | 91.3 |

Notes: Significance calculated using two sample t-tests. "ag." indicates agricultural producers.

and/or glacial stones to protect their streambanks and/or shorelines and native plants to control waterfowl in 2014. They were also more likely to use phosphorus free fertilizers and clean their boats after use to reduce the spread of invasive species in 2014 than in 2010; however, the increases were not significant. Awareness of both rain gardens and rain barrels increased significantly over the four year period for Wabash urban residents. They were also significantly more likely to have installed a rain barrel and pervious pavement.

### Effectiveness of Watershed Level Outreach

Residents (both agricultural producers and urban) of the Upper Tippecanoe Watershed were significantly more familiar with their local watershed organization than residents of the Wabash Watershed (see Table 7). Urban residents of the Upper Tippecanoe Watershed were significantly less likely (13.7%) to have gone to an event than farmers of the Wabash Watershed (28.6%). Urban residents of the Upper Tippecanoe Watershed were significantly more likely than urban residents of the Wabash Watershed to think an event they attended was effective. Lastly, agricultural producers in the Upper Tippecanoe Watershed were significantly more likely to self-report a change in their behavior as the result of attending an outreach event than agricultural producers in the Wabash Watershed.

There were notable differences in how well the outreach impacted targeted residents as well as whether it made any difference in their behavior. Some of the differences, such as the big gap in awareness of the TWF in comparison with the WREC, are likely a result of how samples were obtained. The outreach material that was the most effective at reaching the most respondents overall were TWF News Splash Newsletters. Over half

**Table 5.** Percentage of survey respondents who saw each factor as limiting them a lot. No significant differences were found over time (non-shaded rows). Circles indicate significant differences between resident types in 2014 (shaded rows) at **p<0.01 or ***p<0.001.

| Survey Respondents | Approval of my neighbors | No one else I know is using the practice | Not being able to see a demonstration of the practice | Lack of available information about a practice | Not having the equipment I need | Personal out-of-pocket expenses |
|---|---|---|---|---|---|---|
| All (2010) | 5.4 | 10.5 | 13.1 | 15.7 | 20.9 | 34.5 |
| All (2014) | 5.2 | 9.9 | 11.7 | 17.3 | 22.5 | 31.4 |
| Upper Tippecanoe, ag. (2010) | 5.9 | 6.8 | 6.0 | 10.0 | 23.5 | 46.7 |
| Upper Tippecanoe, ag. (2014) | 5.7 | 2.3 | 7.0 | 12.4 | 28.1 | 33.3 |
| Upper Tippecanoe, urban/lake (2010) | 4.9 | 9.0 | 11.7 | 12.2 | 13.9 | 25.7 |
| Upper Tippecanoe, urban/lake (2014) | 6.2 | 10.2 | 9.9 | 14.6 | 14.8 | 28.4 |
| Wabash, ag. (2010) | 4.8 | 5.7 | 6.9 | 10.1 | 18.6 | 29.4 |
| Wabash, ag. (2014) | 2.7 | 6.5 | 5.9 | 9.5 | 23.8 | 26.2 |
| Wabash, urban (2010) | 6.2 | 17.5 | 22.5 | 26.2 | 29.2 | 43.7 |
| Wabash, urban (2014) | 5.7 | 15.1 | 21.0 | 29.8 | 30.4 | 39.0 |
| All ag. (2014) | 3.6 | **5.2** | **6.3** | **10.4** | 25.2 | 28.5 |
| All urban/lake (2014) | 6.0 | **12.2**** | **14.5**** | **20.8***** | 21.2 | 32.8 |

Notes: Significance calculated using two sample t-tests. "ag." indicates agricultural producers.

**Table 6.** Changes in awareness and usage of conservation practices from 2010 to 2014. Circles indicate significant differences over time at *p<0.05, **p<0.01, or ***p<0.001.

| Watershed, resident type | Conservation practice | % heard of (2010) | % heard of (2014) | % using (2010) | % using (2014) |
|---|---|---|---|---|---|
| Upper Tippecanoe, ag. | Comprehensive nutrient management plan | 61.2 | 72.2 | 18.4 | 27.8 |
| | Cover crops | 98.3 | 97.9 | 53.5 | 51.1 |
| | Approved grazing management plan | **64.4** | **89.3*** | **7.8** | **21.4*** |
| | Restored/enhanced wetlands | 94.8 | 93.1 | 23.5 | 28.7 |
| Wabash, ag. | Conservation tillage | 96.6 | 98.2 | 69.0 | 65.1 |
| | Grassed waterways | 97.3 | 96.9 | 79.6 | 72.4 |
| | Conservation buffers | 91.1 | 87.4 | 46.8 | 44.0 |
| Upper Tippecanoe, urban/lake | Phosphorus free fertilizer on lawn | 83.6 | 86.4 | 31.3 | 37.8 |
| | Protect streambanks and/or shorelines with vegetation and/or glacial stones | **74.8** | **86.0***** | **21.4** | **28.3*** |
| | Native plants to control waterfowl | **36.2** | **50.8***** | **3.0** | **9.0**** |
| | Clean boat and trailer after use to reduce the spread of invasive species | 95.0 | 94.5 | 60.5 | 63.9 |
| Wabash, urban | Rain garden | **41.6** | **51.9*** | 2.3 | 2.6 |
| | Rain barrel | **88.8** | **94.5*** | **2.6** | **8.5*** |
| | Pervious pavement | 47.8 | 47.2 | **1.2** | **4.3*** |
| | Maintaining native plant communities | 60.9 | 65.2 | 10.9 | 13.3 |

Notes: Significance calculated using two sample t-tests. "ag." indicates agricultural producers.

**Table 7.** Percentage of survey respondents who fall into each category by survey, 2014. Different letters within rows indicate significant differences between resident type at *p<0.05, **p<0.01, or ***p<0.001.

| | Upper Tippecanoe, ag. | Upper Tippecanoe, urban/lake | Wabash, ag. | Wabash, urban |
|---|---|---|---|---|
| Heard of local watershed organization*** | 82.5 [a] | 94.0 [a] | 47.3 [b] | 40.7 [b] |
| Attended at least one event** | 19.0 [ab] | 13.7 [b] | 28.6 [a] | 22.4 [ab] |
| Attendees who saw at least one event as effective** | 63.2 [a] | 62.8 [a] | 41.3 [ab] | 28.6 [b] |
| Attendees who changed behavior* | 29.6 [a] | 17.0 [ab] | 10.7 [b] | 13.2 [ab] |

Notes: Significance calculated using ANOVA and Scheffe multiple-comparison test. "ag." indicates agricultural producers.

of the Upper Tippecanoe urban residents who responded to our survey had seen this newsletter. Other outreach materials seen by a high percentage of our respondents were the Healthy Shoreline and Healthy Soils yard signs in the Upper Tippecanoe Watershed. Almost half of all respondents had seen these signs. The outreach events that were perceived as most effective overall were the Two-Stage Ditch Design Field Day in the Wabash, and the Northern Indiana Lakes Festival in the Upper Tippecanoe Watershed, with more than 70% of attendees seeing these events as very effective. Individual farmer meetings with conservation officers were also effective methods for education/outreach. More than 20% of the farmers in the Upper Tippecanoe Watershed had met individually with a watershed conservationist within the past two years prior to responding to our survey. More than half of the farmers who met with a watershed conservationist found the information they gained to be very useful. Of the outreach materials that we asked about in the Wabash urban surveys, more respondents had seen painted rain barrels than any other form of outreach, with more than 37% having seen a painted rain barrel.

## Discussion

The results presented in this paper compare pre and post survey data from two different watersheds in Indiana where substantial outreach was conducted, and highlight the difficulties in changing awareness, attitudes, and behaviors related to water quality. Where other studies have examined what motivates individuals to adopt practices at one point in time (e.g., Brehm et al. 2013; Prokopy et al. 2008), we examined what leads to change over time. We found that awareness of different pollutants did not seem to change with the outreach approaches used, some attitudinal measures changed, constraints to change behaviors remained the same, and some specific behaviors changed – primarily among urban residents.

The finding that residents of all watersheds generally exhibited more positive attitudes towards water quality in 2014 than in 2010 indicates that outreach may be having some intended results. Residents may be slow to implement conservation practices because of costs or other limitations, but the finding that their attitudes are becoming more positive may indicate other benefits to creating water quality outreach. For example, while residents may not be willing to adopt a new practice themselves, they may be more likely to volunteer for a clean-up day or discuss water quality issues with friends or family. Our results highlight the importance of examining differences in water quality attitudes between agricultural and urban/lake residents. For instance, there were important differences in what water impairments they were most concerned about and their general attitudes towards addressing water quality. Urban/lake residents generally had much more positive views towards protecting water resources than agricultural residents.

We also found that some outreach activities seemed to be more successful than others in terms of self-reports of effectiveness. There does not seem to be a pattern about which types of outreach activities were most effective, although field days, festivals, and one-on-one meetings with a conservationist were reported as effective in the Upper Tippecanoe Watershed. Note that field days and festivals in the Wabash Watershed were not reported as effective, however, highlighting the importance of understanding local context. It is possible that working in a lake watershed is quite different than working in a non-lake watershed in terms of what outreach efforts will be effective. Newsletters, signage and painted rain barrels were all reported as being visible by survey respondents and may be a helpful way to start raising awareness.

There was a large difference in familiarity with watershed groups between the watersheds, particularly with urban residents, but this may be a result of how the survey samples were generated. A list of lake residents in the Upper Tippecanoe Watershed was provided by TWF, but in the Wabash Watershed a sample was purchased from an outside organization.

Urban/lake residents were more likely to have significantly increased their usage of target practices than farmers. In both the Upper Tippecanoe and Wabash Watershed there were significant increases in the usage of (and often awareness of) two out of four practices. There were no changes in conservation practice uptake or awareness among agricultural producers in the

Wabash Watershed over this time and change for only for one practice - use of approved grazing management plans - among farmers in the Upper Tippecanoe Watershed. We suspect that this is the result of more intense outreach conducted in both watersheds geared towards urban/lake residents. The outreach to urban/lake residents was also information they had likely not heard before, while agricultural audiences have been receiving similar information for years from other entities. We saw the greatest increase in positive attitudes towards water quality among urban residents in the Wabash Watershed, which might be related to their relatively high increase in uptake of conservation practices.

There are numerous limitations inherent in any type of longitudinal study that need to be considered in interpreting our results. (1) Actual environmental conditions in the areas studied may change during the study period. In these two locations, no substantive changes occurred so we do not believe this to be a threat to our conclusions. (2) Other efforts to change awareness, attitudes and increase practice adoption might have occurred in the study areas. Again, we do not believe this happened in these two study areas. Both WREC and TWF worked closely with other entities in their areas on events that are discussed here. (3) Our pre and post measures are all self-reported. This is potentially problematic for many reasons, including the notion that as education about water quality and conservation practices increases in an area, there may be a tendency for respondents to overinflate practice awareness and adoption as a socially desirable response. (4) Other factors can influence people's attitudes over time. For example, if the economy in a local area is stronger in the second time period, respondents might be more likely to report a willingness to pay for water quality improvements even if their underlying beliefs about the importance of water quality have not changed.

## Conclusion

Despite the potential limitations mentioned above, our findings lead to recommendations for future outreach at the watershed level aimed at improving urban and agricultural residents' knowledge about and usage of conservation practices. We recommend surveying the same people over time to learn how their perception of water quality and usage of conservation practices change (Genskow 2012). Watershed groups should conduct interviews or surveys that dig more deeply into why events are not seen as effective directly after or during educational events in order to gauge participants' perceptions of an event while the event is still fresh in their memory. Watershed groups should use event-specific surveys, asking attendees about their knowledge of the target BMP before and after the event in order to gauge the effectiveness of the event. We realize that other factors may account for the changes in attitudes and behaviors we have documented, so further studies would need to be conducted asking different questions about their perceived barriers to implementing a practice, and perhaps some focus groups should be conducted to gain further insight using more qualitative data. We recommend the use of practice-specific outreach to address the most common barriers associated with each individual practice. Stakeholder-specific outreach to address barriers perceived by specific stakeholder groups would be useful. Lastly, with regard to agricultural residents, we would recommend one-on-one farmer contact with conservation officers, as this was one of the most successful means of outreach in the Upper Tippecanoe River watershed.

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# Developing Great Lakes Literacy and Stewardship through a Nonformal Science Education Camp

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**Abstract:** Informal science education has received great attention nationally in recent years, however little has been included in the research or policy literature regarding camps as contexts for informal learning. This article first describes how a Great Lakes water resource education camp is based upon professional definitions of informal, nonformal and formal education. Next, we describe specific details of our long-running Michigan 4-H Great Lakes and Natural Resources Camp designed to foster teen leadership and watershed stewardship. The Camp utilizes research-based best practices in nonformal science education, Place Based Education, Great Lakes Literacy education, and environmental education, as we demonstrate through detailed literature review. We also provide details of quantitative impact evaluation conducted between 1999 and 2012 and involving over 700 youth participants. Youth received pre-Camp and immediate post-Camp surveys. The Camp had a positive impact on teens' Great Lakes literacy, place attachment, and stewardship intentions. We conclude with recommendations for designing nonformal water literacy education, based on guidelines from the National Research Council and from our experiences, to enhance whole-person development and deep learning through nonformal camp-based programs.

**Keywords:** *Great Lakes literacy, aquatic resource stewardship, nonformal environmental education, aquatic resource education, camping programs, place attachment, youth education*

Nonformal science education is increasingly important to prepare today's youth for active civic engagement in preventing and resolving resource issues of local, regional and global importance. Various types of nonformal environmental education (NFEE) have been used to foster lifelong stewardship; one of the most ubiquitous of these NFEE experiences for youth is attending summer camp. And, what summer camp does not offer direct learning contact with water resources? Camps of all sorts, not just NFEE-oriented camps, foster learning through activities such as: water-based recreation (canoeing, swimming), "nature study," crafts, and campfires by a scenic lake or other natural setting. As numerous researchers have noted, diverse childhood experiences (such as NFEE within natural areas, with peers and mentors in youth organization-sponsored learning environments) can have positive influence on a person's later actions in regard to sustaining environmental quality (Wells and Lekies 2006; Chawla 1999; Tanner 1980).

In spite of the commonality of youth camps, this form of programming receives little mention within the recent literature regarding nonformal or informal science education. Informal science education is defined according to the nature of the venue where learning primarily occurs; these include informal, everyday settings (at home, through media, playing educational games, hobby-related learning, or volunteering), designed environments (zoos and aquaria, nature centers, museums or science centers), and programs (through clubs, after-school activities, and citizen science) (Fenichel and Schweingruber 2010; National Research Council 2009). Missing in this categorization is the youth camp, which would certainly be a common form of informal program environment.

Informal science education is noted for its importance by the National Research Council

for many reasons; most notably, learners spend only a small proportion of their time in formal learning environments (pre-K, K-12 and post-secondary institutions). Furthermore, formal schooling continues to be fraught with challenges and uncertainties tied to standardized curricula and high stakes testing; these foci cause stress and are time-consuming for school-based educators (Edwards and Springs 2014). Gruenewald and Manteaw note that "one consequence of the 'high-stakes' environment…is that the pressure to prepare for tests inhibits the development of outdoor, experiential, project-based learning, or community-based learning….there are fewer opportunities to participate in collaborative inquiry projects, to contribute to community problem-solving, or to be initiated into the political process" (2007: 181).

Informal science camps present tremendous opportunities for water resource education. The purpose of this article is threefold:

1. We explore the definitions of nonformal, informal and formal science education in the EE and science education literature, and apply these definitions to camp programming focused on Great Lakes resources.
2. We describe the program model for and the quantitatively-documented impacts of a particular Great Lakes and Natural Resources youth camp, co-sponsored by 4-H Youth Programs, Sea Grant, Michigan State University and agency and community-based partners.
3. We conclude with recommendations for nonformal science learning through camps designed to foster whole-child youth development and lifelong commitments to water stewardship in the Great Lakes region.

## Background: Nonformal, Informal and Formal Science Learning and Youth Camps for Water Resource Understanding and Stewardship

Many studies have identified the learning impacts of conservation education camps. These programs provide intense contact with mentors and result in development of youths' favorable attitudes toward the environment and management of natural resources, internal locus of control, knowledge of ecology, and environmental stewardship (Kruse and Card 2004; Mittelstaedt et al. 1999; Dettman-Easler and Pease 1999; Hanna 1995; Dresner and Gill 1994; Carlson and Baumgartner 1974). The impacts of camp programs on youth learning and personal development are well documented by the American Camp Association (2015).

Some camp programs could be considered mostly formal education – associated with K-12 education systems. The practice of "school camping" emerged in the 1950s as an effort to expose youth to outdoor living and skill development. Such camps are organized by school personnel and attended by youth during the school year and during the week. School camping still exists today, offered by K-12 districts/systems that maintain their own camp properties or that rent camp facilities from other organizations.

Most youth camps, however, would typically be classified as nonformal learning contexts. Scholars have long found it useful to define nonformal and informal learning differently. Maarschalk (1988) offered these definitions:

- "Informal education applies to situations in life that come about spontaneously…These are reflected in what a person is reading, viewing, and listening to and also in his or her hobbies.
- Nonformal education proceeds in a planned but highly adaptable way in institutions, organizations, and situations outside the sphere of formal schooling" (p. 139).

Researchers working in the 1990s noted that informal and formal education systems are characterized by different features, including these:

- The learning atmosphere (e.g., non-school institution for nonformal settings, and no special institution for informal learning).
- The party responsible for managing the learning (informal science is learner-managed, whereas nonformal learning is educator-mediated) (Tamir 1990-91).

Both nonformal and informal education experiences are associated with learners developing a strong commitment to science and science learning (Tamir 1990-91).

By the mid-2000s, researchers and practitioners alike distinguished between nonformal and informal learning with a research-based classification of educational terminology called The Definitions Project (2007). This work was funded by the U.S. Environmental Protection Agency, and facilitated by the National Association for Interpretation to provide a collaboratively-generated, common vocabulary for those working within education and interpretation in a variety of settings. The Definitions Project (2007) involved dozens of diverse federal agencies, professional associations, and conservation non-profit organizations. The resultant definitions of formal, nonformal and informal education are similar to the original 1980s classifications, but offer more refined detail in order to provide research-based guidance to those designing educational initiatives. Most recently, the National Research Council lumps both nonformal and informal settings into what it terms "informal science education," then distinguishes among types of learning by classifying these as "everyday learning," "designed environments," or "programs" (NRC 2009). For specific, contemporary definitions, see Table 1.

Although early scholars considered education systems as arrayed along a continuum ranging from formal, to nonformal to informal, Figure 1 depicts a perspective showing interfaces among these systems. This representation is useful in that it shows that programs such as a water science camp are not easy to classify in only one realm. Rather, we see work in water resources education as situated mainly in the interface between nonformal and informal learning, with significant links and ties to formal learning contexts (Figure 1).

As an example of water science education programs that intersect informal, nonformal and even formal education approaches, this article presents the Michigan 4-H Great Lakes and Natural Resources Camp (for teens ages 13-15, and offered since 1985). This Camp is mostly presented as a nonformal science education program; it has clear organization and planning for nonformal learning that is mentored by staff and counselors during a one-week residential experience. The program exhibits best practices in informal science learning in association with parks, maritime museums, and other local community partners. Informal learning at Camp is also accomplished through

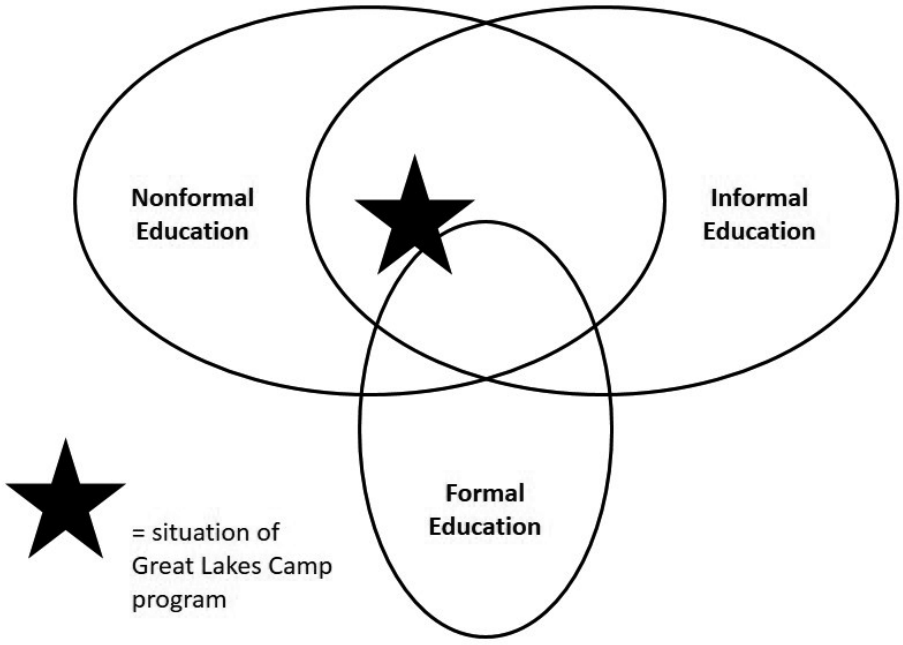


**Figure 1.** Situating the Michigan 4-H Great Lakes and Natural Resources Camp program within the realms of nonformal, informal and formal science learning.

**Table 1.** Definitions of informal, nonformal and formal science education.

| Concept/ Term | Defining Entity/Organization | | |
|---|---|---|---|
| | Journal of Environmental Education (Tamir 1990-91)* | Definitions Project (U.S. EPA and National Association of Interpretation) (2000s)** | National Academy of Sciences and National Research Council (2010)**** |
| **Informal Learning** | *Place*: no special institution, home<br>*Learning environment*: not arranged<br>*Attendance*: voluntary<br>*Subject matter*: not structured<br>*Motivation of learners*: mainly intrinsic<br>*Managers of learning*: learners<br>*Assessment*: none | "The truly lifelong process whereby every individual acquires attitudes, values, skills, and knowledge from daily experience and the educative influences and resources in his or her environment – from family and neighbors, from work and play, from the market place, the library, and the mass media."***<br>Informal learning environments [include'] the places, venues, and settings where informal learning opportunities are intentionally made available to visitors, such as in parks or museums. | Only defines "informal science learning"<br>Everyday Learning:<br>Experiences occur over a lifetime, include family activities, walks, hobbies, media, helping with outdoor tasks (farming, gardening)<br>Designed Environments:<br>Museums, zoos, aquaria, visitor centers, nature centers, historic settings, libraries, botanical gardens, science centers<br>Programs:<br>Afterschool programs, clubs, volunteer groups, citizen science projects, educational vacations, summer programs |
| **Nonformal Learning** | *Place*: non-school institution<br>*Learning environment*: pre-arranged<br>*Attendance*: voluntary<br>*Subject matter*: structured<br>*Motivation of learners*: typically intrinsic<br>*Managers of learning*: both mentors and learners<br>*Assessment*: not expected | "Any organized educational activity outside the established formal system – whether operating separately or as an important feature of some broader activity – that is intended to serve identifiable learning clienteles and learning objectives."*** | |
| **Formal Learning** | *Place*: school-based, classroom, pre-K, K-12, postsecondary<br>*Learning environment*: pre-arranged<br>*Attendance*: compulsory<br>*Motivation of learners*: typically extrinsic<br>*Management of learning*: teacher<br>*Assessment*: expected | "The hierarchically structured, chronologically graded 'education system, running from primary school through the university and including, in addition to general academic studies, a variety of specialized programs and institutions for full-time technical and professional training."** | Science learning that takes place in schools |

*Adapted from Tamir (1990-91).

**The Definitions Project (2007), http://www.definitionsproject.com/definitions/media/definitions_list_0107.pdf.

***Adapted by The Definitions Project from The Encyclopedia of Informal Education, 2006 http://www.infed.org/encyclopaedia.htm.

**** Fenichel and Schweingruber 2010; National Research Council 2009.

free choice learning options offered to youth to explore recreational and avocational interests related to water resource recreation. Finally, the Camp clearly links its learning outcomes to formal, K-12 state science curriculum expectations, and communicates these to parents and to teachers who recruit campers; this is done by aligning the camp's lessons to the Michigan K-12 Grade Level Content Standards in Science (revised according to Michigan's adaptation of the Next Generation Science Standards). In addition, the Camp is a formal component of Michigan State University's network of "pre-college" programs, thus providing college preparation and career/major exploration for its participants. In summary, then, there are possibilities and benefits to considering the overlap and linkages among nonformal, informal and formal science learning contexts, as opposed to viewing each as mutually exclusive learning platforms, for enhancing youth water resource science understanding and stewardship.

## Nonformal Water Resources Education Model: The Michigan 4-H Great Lakes and Natural Resources Camp for Teen Leadership

The Michigan 4-H Great Lakes and Natural Resources Camp is a one-week environmental leadership program that provides opportunity for youth ages 13-15 to become involved in Great Lakes-related learning regarding water science resource issues, career opportunities, and lifelong recreational interests. Attendees consist of campers from throughout Michigan, most of whom enter eighth through tenth grade the following school year.

The Camp utilizes research and best practice in nonformal science education by providing highly experiential and site-specific learning. The program goals are to:

- Increase youth knowledge about local and Great Lakes regional aquatic and natural resources ecology and management issues.
- Provide diverse role models for youth from among local and Great Lakes regional volunteer, agency and Extension staff.
- Engage youth in field trips to unique local Great Lakes ecological sites where they can meet diverse community experts and volunteers.
- Foster advanced leadership opportunities (for campers to progress to counselor, and ultimately to instructional staff) and through which campers can share their Great Lakes experiences and expertise with others.

The program is situated along Lake Huron in northeast Michigan. Ecosystem features at the site include: rare coastal wetlands, shoreline, inland lakes and rivers, cultural resources such as lighthouses and shallow-water shipwrecks, a marina, swimming and fishing access, animal and plant biodiversity, the world's largest open limestone quarries and unique fossils such as Petoskey stones. Local natural areas, research and management facilities operated by Michigan Department of Natural Resources, U.S. Fish and Wildlife Service, the National Oceanic and Atmospheric Administration and local organizations provide place-centered field learning opportunities. The specified objectives of the program are that youth will:

- Increase their appreciation and enjoyment of the outdoors, natural resources, and science.
- Increase their understanding of natural resource ecology and management.
- Learn to teach about and provide leadership in natural resources, especially the aquatic environment and the Great Lakes.
- Become stewards in local natural resources projects.
- Develop career and personal interests in natural resources, ecology and management.

These outcomes are purposefully aligned with the Great Lakes Literacy Principles (Fortner and Manzo 2011; http://greatlakesliteracy.net/). This research-based, extensively peer-reviewed framework defines a Great Lakes literate person as one who:

- Understands the essential principles and fundamental concepts about the characteristics, function and value of the Great Lakes.
- Can communicate accurately about the Great Lakes' influence on systems and people in and beyond their watershed.

- Makes informed and responsible decisions regarding the Great Lakes and the resources of their watershed (http://greatlakesliteracy.net/).

At the Michigan 4-H Great Lakes Camp, youth take part in five ecology sessions during the week that foster Great Lakes literacy. Using best practice in nonformal education (National Research Council [NRC] 2009), generalized lesson plans with specific learning outcomes and teaching options are used during the morning ecology sessions. There is not a formal "curriculum," so instructors (university, agency or conservation partner personnel) have the flexibility to highlight site-specific "teachable moments" given the ecological features and management dilemmas presented at the Lake Huron areas used in instruction. In addition, morning sessions emphasize career opportunities related to various sciences. Examples of these Great Lakes literacy morning sessions include: Great Lakes Fisheries and Charter Fishing, Great Lakes Coasts/Wetlands, Great Lakes Watersheds (Limnology), Great Lakes Region Forests and Wildlife, Great Lakes Geography (using GPS), and Great Lakes History and Maritime Heritage.

Youth do more than simply learn about Great Lakes aquatic resource sciences. They also participate actively in citizen science initiatives with real-world community partners. For example, youth have collected data regarding the threatened Pitcher's thistle, and contributed their findings to the Michigan Natural Features Inventory and the U.S. Fish & Wildlife Service (USFWS). Campers have worked with the USFWS to collect data on distribution of the invasive, non-native *Phragmites*. Another partnership between Camp and the U.S. Geological Survey's Great Lakes Science Center provides youth-collected data relevant to its Lake Huron Predator Diet Study. Additional stewardship service projects for campers offer models for efforts they can undertake as real-world application of their science learning when they return to their own home communities, working with conservation partners and civic organizations locally.

These camp program elements are designed to espouse and follow best practices in Place Based Education (PBE). Smith (2002) notes that PBE aims to "ground learning in local phenomena and students' lived experiences." The Great Lakes Stewardship Initiative notes that PBE uses the local community and environment as a starting place for teaching and learning; PBE also fosters learning that is hands on, inquiry-based, real-world, experiential, and in direct collaboration with community partners (www.glstewardship.org). Many other scholars and practitioners have defined PBE, including Sobel (1996, 2004), Gruenewald (2003), Gruenewald and Smith (2008), Great Lakes Water Studies Institute (2005), The Rural School and Community Trust (2014), and Woodhouse and Knapp (2000). In its report, the NRC validates the "place-centered lens" as one way to understand and situate learning within informal environments (2009).

Each afternoon, youth choose from a variety of place-specific, natural resource-based recreation or field trip options. This is the portion of the Camp program that could be most considered the informal science learning component. Participants have free choice in signing up for their learning interests, and have a great deal of time to explore and learn on their own. Water-based recreation includes: sailing, canoeing, kayaking, snorkeling, wading, and swimming. Field trips take participants to local museums, a National Marine Sanctuary and visitors' center, natural areas, and other trail or exploration sites. Afternoon Camp sessions thus utilize best practices in offering participants Free Choice Learning – "the type of learning guided by a person's needs and interests… learning that people engage in throughout their lives to find out more about what is useful, compelling, or interesting to them" (The Definitions Project 2007, p. 5, adapted from the Institute for Learning Innovation).

Evening programs at Camp develop ownership and empowerment for specific stewardship actions, such as teaching others about the Great Lakes or participating in local or state environmental policy making. Each evening, a campfire program offers a close to the learning for the day. Campfire programs, like all elements of this nonformal science experience, are carefully planned to serve the purposes of reflecting on science learning, developing a sense of belonging to camp community life, and fostering sense of place and attachment to the Great Lakes region. Songs and stories focus on the day's happenings, Great Lakes tales, themes of stewardship and responsibility to one another, and community spirit.

The design for this nonformal science program is based on research by Hungerford and Volk (1990), and on Marcinkowski's logic model for environmental education (2004). This camp strives to develop a strong attitudinal attachment to the significant bioregional features surrounding Michigan (four of the five Great Lakes), and the state's unique natural resources in the form of fisheries, coastal regions, watersheds, wetlands, wildlife, and forests.

## Impact Evaluation of the Nonformal Great Lakes Camp

Great Lakes Camp program staff members administered pre- and post-camp surveys from 1999-2012; each survey took participants approximately 40 minutes to complete. The pre-survey was administered at camper check-in, and the post-survey was given during the last evening of camp. Survey questions were adapted from existing studies (Table 2).

Camper assent and parental consent for completion of the surveys has been consistently 100%. Each year, however, some pre-surveys cannot be matched with camper post-surveys, and some respondents do not complete all parts of the surveys. The proportion of unusable cases is less than 5% every year. A total of 736 usable pre- and post-camp cases were compiled from 1999 through 2012, and allow for analysis of Great Lakes literacy (Table 2). Great Lakes place attachment questions added in 2005 resulted in 494 usable cases for analysis. Post-camp questions regarding Great Lakes stewardship intentions were used from 1999-2012 with all respondents; beginning in 2004, the evaluation process used additional questions, both pre- and post-camp. One set of added questions concerned career and other intentions. Another set pertained to what Marcinkowski and Rehrig (1995) term locus of control; these questions assess the respondents' beliefs regarding their capacity for particular stewardship intentions (Table 2). Decades of previous research have noted that

**Table 2**. Sources from which impact evaluation questions were adapted, years items used, and number of usable survey cases.

| Content of questions | Survey items adapted from: | Camp years during which survey items were used | Number of usable survey cases |
|---|---|---|---|
| Great Lakes literacy (see Table 3) | Williamson and Dann 1999; Fortner and Teates 1980; Fortner 1993 | 1999-2012 | 736 |
| Great Lakes regional place attachment (see Table 4) | Vaske and Kobrin 2001; Williams and Vaske 2003 | 2005-2012 | 494 |
| Great Lakes stewardship attitudes and behavioral intentions (see Table 5) | Williamson and Dann 1999; Zint and Hanson 2002; | Two items used 2004-2012<br>One item used 2006-2012 | 543<br>439 |
| Stewardship capacities for environmental or water-related actions (see Table 6) | Marcinkowski and Rehrig 1995 | 2004-2012 | 543 |
| Self-perceived Great Lakes Stewardship attitudes and behavioral intentions (post-Camp only items; see Table 7) | Williamson and Dann 1999; | 1999-2012 | 736 |

intention to act is a strong precursor to stewardship behavior, thus intentions represent important, immediate post-camp variables (Hungerford and Volk 1990). Given our focus on natural resource teen leadership, for this assessment, stewardship intentions were operationalized as campers' interest in and plans to communicate with others about the Great Lakes, to participate in service projects, and to consider Great Lakes or related careers.

Each camper's pre- and post-camp tests were matched, using the camper's name. The data were then stripped of identifiers to maintain respondent confidentiality. Data were analyzed using SPSS (version 22). The authors used Cronbach's Alpha to ascertain place attachment scale reliability. Analysis included chi-square to investigate differences between pre- and post-test frequencies, and paired t-tests to identify statistically significant changes in mean scores for pre- and post-camp Great Lakes literacy, sense of place, and stewardship.

Fifty-six percent of camp participants are male and 44% are female. About two-thirds of respondents (69.2%) were new campers; 30.8% of cases were campers returning for their second or third year.

Great Lakes literacy increased significantly among the campers as a result of this nonformal water science education program. The mean pre-camp total score was 11.2 (standard deviation 2.9), out of a possible 16 points; the post-camp mean was 12.6, and the standard deviation decreased to 2.5 (Table 3). Only 62.0% of campers scored 11 or higher on the pre-test, but 81.2% gained this score on the post-test.

Although there are many ways to conceptualize and operationalize "sense of place," various scholars have observed the importance of developing learners' sense of place and other attitudinal attributes, in addition to scientific literacy, as precursors to stewardship (Farnum et al. 2005; Vaske and Kobrin 2001). Vaske has worked with various colleagues to operationalize sense of place as "place attachment," which consists of two factors: a) place dependence – a functional connection to place that reflects the importance of a resource in providing amenities for desired activities; and b) place identity – an emotional connection to place that represents a psychological investment with a setting developed over time leading to a component of one's self-identity (Vaske and Kobrin 2001; Williams and Vaske 2003).

Items from Vaske's research were modified to relate specifically to Great Lakes place attachment, and when used with this set of respondents, scale reliabilities (Cronbach's Alpha) ranged from 0.872 to 0.897 (Table 4). Among Great Lakes Campers, both place dependence and place identity scores increased significantly, showing that youth gained a strong sense of place in their Great Lakes bioregion as a result of this nonformal education program (Table 4). Campers' mean total place dependence scores increased from 16.09 to 17.29 (out of a possible score of 20). Likewise, total place identity scores increased from 11.61 to 12.65 (out of a possible score of 15) (Table 4).

Camp affected youths' Great Lakes stewardship intentions, an important outcome desired for this program. The percentage of campers agreeing that they would like to communicate with others about camp increased from 71% pre-camp to 87% post-camp. Similarly, 70% of pre-camp respondents indicated they would use information from camp in projects or teaching others, whereas this proportion increased to 87% post-camp. Fewer campers indicated they would consider careers related to the Great Lakes, (55% pre-camp vs. 64% post-camp). Regardless, all of these pre- vs. post-camp changes in intentions were highly statistically significant (paired t-test, $p<0.001$) (Table 5).

Pre- vs. post-camp self-assessments of capacity for influencing solutions for environmental issues, and for giving a Great Lakes lesson or presentation to others increased significantly. The proportion of campers believing they can influence solutions of environmental issues either on their own or acting with others increased a small amount (7.6% – alone and 13.3% – with others, respectively), however, 86% of campers reported strong post-camp capacity to influence issues by acting with others (Table 6). There was a much greater self-perceived change in capacity (knowledge and confidence) to give a presentation or lesson to others about the Great Lakes; about 44% reported strong capacity for these intentions pre-camp, whereas 78% reported this capacity at the end of camp (Table 6).

Finally, a battery of post-camp only questions about stewardship intentions show meaningful impacts of camp programming on water science

**Table 3.** Great Lakes literacy, pre- vs. post-camp. Items used 1999-2012, with 736 usable cases.

| Question (T=True, F=False) | Pre-Camp | | Post-Camp | |
|---|---|---|---|---|
| | % Correct | % Undecided | % Correct | % Undecided |
| An important difference between oceans and most lakes is that oceans are salty. (T) | 84.9 | 5.5 | 86.5** | 4.5 |
| The reason you can find fossil clam shells on the top of some mountains is that area was once under water. (T) | 76.7 | 17.7 | 87.2** | 8.5 |
| On a hot summer day, air over the beach is the same temperature as air over Lake Huron. (F) | 67.2 | 26.4 | 72.3** | 17.0 |
| The Edmund Fitzgerald was an ore boat that sank in Lake Superior. (T) | 58.4 | 29.3 | 76.1** | 9.1 |
| Marshes are disappearing because people are filling in the marshes for homes, farms and businesses. (T) | 78.0 | 17.6 | 88.4** | 8.1 |
| The sucker is a parasitic fish found in the Great Lakes. (F) | 21.9 | 33.7 | 33.9** | 23.6 |
| Sea lampreys have been a problem in the Great Lakes because they suck blood from lake trout and other fish. (T) | 72.7 | 21.7 | 93.0** | 4.2 |
| Plankton are non-living substances in the sea or the Great Lakes. (F) | 68.5 | 18.6 | 76.3** | 9.7 |
| Beaches are safe and beautiful places to build houses. (F) | 71.0 | 20.4 | 78.6** | 12.4 |
| Algae are plants that live in water. (T) | 87.5 | 6.6 | 90.7** | 4.9 |
| Fish have lungs. (F) | 61.2 | 10.7 | 70.3** | 7.2 |
| People are necessary for the water cycle to work. (F) | 62.9 | 19.9 | 65.1** | 12.7 |
| Less than 25% of the water on Earth is fresh water. (T) | 76.2 | 14.5 | 90.5** | 4.6 |
| This is a food chain in the correct order: water...insects…fish…water plants…people. (F) | 80.6 | 12.3 | 84.9** | 8.1 |
| People should eat Great Lakes fish only once in awhile because very few fish live in the Great Lakes. (F) | 59.2 | 29.2 | 64.7** | 22.8 |
| Forests and wetlands help keep the water in the Great Lakes clean and clear. (T) | 63.5 | 27.7 | 79.7** | 15.1 |
| **MEAN (standard deviation) total score (max 16)** | 11.2 (2.9) | | 12.6 (2.5)** | |
| **Mean total score converted to % correct** | 69.8% | | 78.6% | |
| **Campers receiving a "passing score" of 11/16 or greater** | 62.0% | | 81.2% | |

**=Statistically significantly different, Chi-square test comparison of frequencies (1 d.f.) or paired t-test comparison of means, $p<0.001$.

**Table 4**. Great Lakes regional place attachment, pre- vs. post-camp. Items used 2005-2012, with 494 usable cases. Rows referring to Great Lakes Place Dependence are shaded. Rows referring to Great Lakes Place Identity are non-shaded.

| Question | Pre-Camp Mean* (sd) | Post-Camp Mean* (sd) |
|---|---|---|
| ***Great Lakes Place Dependence*** | | |
| The Great Lakes are the best place for what I like to do. | 3.79 (1.03) | 4.11 (1.00)** |
| I get a lot of satisfaction out of visiting the Great Lakes. | 4.21 (0.86) | 4.48 (0.79)** |
| I would not trade the Great Lakes for any other region. | 4.09 (1.11) | 4.36 (0.97)** |
| No other place can compare to the Great Lakes region. | 3.97 (1.18) | 4.31 (0.99)** |
| **MEAN total score (max=20)** | 16.09 (3.57) | 17.29 (3.19)** |
| **Reliability (alpha)** | 0.872 | 0.897 |
| ***Great Lakes Place Identity*** | | |
| I think often about coming to the Great Lakes. | 3.79 (1.14) | 4.13 (1.07)** |
| I am very attached to the Great Lakes region. | 3.92 (1.10) | 4.30 (0.96)** |
| I identify with the Great Lakes. | 3.86 (1.14) | 4.18 (1.01)** |
| **MEAN total score (max=15)** | 11.61 (3.07) | 12.65 (2.75) ** |
| **Reliability (alpha)** | 0.872 | 0.896 |

*Where 1=strongly disagree, 5=strongly agree.
**=Statistically significantly different, paired t-test, $p<0.001$.

**Table 5.** General changes in Great Lakes stewardship attitudes and behavioral intentions.

| Question | % of Campers agreeing | | Mean* (sd) | |
|---|---|---|---|---|
| | Pre-Camp | Post-Camp | Pre-Camp | Post-Camp |
| I would like to share this camp with others.[a] | 71.5 | 87.1 | 4.15 (1.01) | 4.50 (0.91)** |
| I am interested in a career that is outdoors, working with the Great Lakes, marine biology, or connected to any type of environmental science.[a] | 55.5 | 63.7 | 3.65 (1.31) | 3.86 (1.26)** |
| I will use the information I learn at Camp in school, in other types of projects, or by teaching others.[b] | 70.5 | 87.4 | 4.11 (1.02) | 4.44 (0.90)** |

*Where 1=strongly disagree, 5=strongly agree.
[a]Item added in 2004, with 543 usable cases.
[b]Item added in 2006, with 439 usable cases.
**=Statistically significantly different, paired t-test, $p<0.001$.

**Table 6.** Self-perceived changes in stewardship capacities for environmental or water-related actions. Items added in 2004, with 543 usable cases.

| Question | % Campers Agreeing (answering 4 or 5*) | | Mean Score* (sd) | |
|---|---|---|---|---|
| | Pre-Camp | Post-Camp | Pre-Camp | Post-Camp |
| To what extent do you believe that you can influence the solution of an environmental issue by acting on your own? | 47.9 | 55.5 | 3.43 (0.99) | 3.64 (1.04)** |
| To what extent do you believe that you can influence the solution of an environmental issue by acting with others? | 73.0 | 86.3 | 4.09 (0.92) | 4.44 (0.80)** |
| To what extent do you feel knowledgeable about how to give a lesson or a presentation about nature, the environment, or Great Lakes Camp to others? | 44.1 | 78.8 | 3.34 (1.06) | 4.17 (0.84)** |
| To what extent do you feel confident that you are able to give a lesson or a presentation about nature, the environment, or Great Lakes Camp to others? | 43.6 | 78.1 | 3.24 (1.19) | 4.16 (0.89)** |

*Where 1=no extent, 3=moderate extent, 5=a great extent.
**=Statistically significantly different, paired t-test, $p<0.001$.

**Table 7.** Post-camp stewardship intentions. Items used 1999-2012, with 736 usable cases.

| Question | % Campers Agreeing |
|---|---|
| ***Leadership and Communications (Persuasion)–Personal Responsibility*** | |
| I will apply to be a Great Lakes Camp counselor in the future. | 75.7 |
| I plan to teach others some of the activities and information I learned here at Camp. | 80.3 |
| I'll share my Camp experience with local groups by making a presentation. | 49.8 |
| I will tell other teens about Camp, and encourage them to be Campers next year. | 81.1 |
| I will contact some of the adult camp instructors to learn more in the future. | 48.1 |
| ***Knowledge Application*** | |
| I think I'll use some of the information I learned at camp in my 4-H projects or in my school projects. | 81.8 |
| I plan to work with others to do a community service project next year to improve the environment. | 67.5 |
| I plan to use the information I learned at Camp over the next 6 months. | 79.8 |
| ***Career Choice*** | |
| I plan to choose a career related to the Great Lakes. | 41.6 |
| I plan to choose a career in natural resources or environmental science. | 49.2 |
| I plan to choose a career in science. | 56.4 |
| ***Outdoor Recreation*** | |
| I plan to take part in more outdoor activities (sailing, etc.) in the future. | 86.2 |

actions and career choice (Table 7). High proportions (70-80%) of campers indicate they will communicate about and use the information from camp in future actions. Although smaller proportions (42-56%) indicate career choice interests related to the Great Lakes, natural resources/environmental sciences or science in general, this is to be expected since campers are only 13-15 years old (Table 7).

Overall, nonformal water science education programs, when carefully and intentionally planned and executed, can have significant impacts on learners' water literacy, place attachment to water resources, and intentions for further stewardship actions. The challenge, then, is making sure that camp programming is informed from sound research and best practices in science education for informal and nonformal audiences.

## Discussion and Recommendations for Nonformal Water Education Programming

This in-depth analysis of impacts of a Great Lakes nonformal science education program provides insights into research-based, evidence-based programming. Yet, this evaluation also has its limitations. Funding constraints have prevented 3-6 month follow-up studies, which other scholars have used to investigate long-term influences on youth learning (e.g., Bogner 1998). Some evaluators have used parents' perceptions of lasting program impacts as a proxy for direct measures of long-term learning of youth (e.g., Ballentyne et al. 2001); this method has been used once with our Michigan Great Lakes camp, but response rates for these methods are typically low. Instead, as co-authors we have chosen to establish a dataset large enough to allow for causal modeling of program-related learning factors that have strong influence on Great Lakes stewardship intentions; this analysis is planned for the near future.

One goal of informal and nonformal science education concerning water resources is to create strong, scientifically-grounded environmental stewards familiar with the unique characteristics of their locale and their bioregion. We make the following recommendations regarding nonformal camp programming designed to foster water science literacy and stewardship.

- *Develop a unique, research-based niche for your water resources education camp, and evaluate impacts on water science learning.* Today's youth camp programs have essential learning niches to fill. The American Camp Association (ACA 2015) stresses the importance of intentional education planning and risk management, based in sound social science.
- *Communicate with staff and sponsors that "nonformal" does not mean "unplanned," "spontaneous" or "laissez faire" learning contexts!* Rather, nonformal and informal science learning programs such as camps have detailed lessons and desired outcomes linked to school learning standards in science, while at the same time offering flexibility for learners to explore dramatically new interests in a non-school setting. Furthermore, programs like our camp, linked with a university, offer unique opportunities to try pre-college learning situations, with stimulating learning provided by university faculty/staff as well as water research, agency and organization partners.
- *Have an explicit purpose for every component of a nonformal water resource education program*, including what are typically considered "down times" (recreation sessions, campfire). In the case of our camp program, we align the purposes of each scheduled component with explicit program desired outcomes, and with the evaluation items used to assess near-term impacts. For example, morning sessions focus on Great Lakes literacy, afternoon and campfire programs focus on place attachment, and evening sessions focused on leadership prepare learners for stewardship actions such as communication about Great Lakes water resource topics. Our evaluations document that we achieve these explicit objectives with our nonformal water science education.
- *Tie the purposes of program components to the essential six strands for informal science learning identified by the National Research Council* (2009, p. 4). This action will ensure rigor and relevance given the broader findings of science education research.

The six strands for informal science learning (NRC 2009) can be used as a lens to examine our Great Lakes Camp as follows:

*Strand 1: Learners experience excitement, interest and motivation to learn about phenomena in the natural and physical world (NRC 2009, p.7).*

The Great Lakes Camp provides variety in aquatic resource science learning opportunities, such as learning in the field, making use of "teachable moments" that the learning site provides (e.g., invasive species), and integrating technology (GPS, photography), the arts (traditional maritime and Great Lakes songs), and water-based recreation to spark interest in water resources and aquatic sciences.

*Strand 2: Learners come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.*

*Strand 5: Learners participate in scientific activities and learning practices with others, using scientific language and tools (NRC 2009, p.7).*

Campers develop understanding, using scientific content and knowledge for explanations of Great Lakes issues and phenomena through their morning ecology sessions with aquatic scientists. Campers also use the tools and language of science by recording measurements of ecological phenomena and contributing to long-term citizen-science databases used by resource professionals. Learning sessions are rigorous, with science concepts and vocabulary tied to research-based frameworks (e.g., state science content and process standards, Great Lakes Literacy Principles 2010).

*Strand 3: Learners manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world (NRC 2009, p.7).*

Campers engage in scientific reasoning, learn by doing, and describe their reasoning to peers and mentors through conversations, journaling, photography and other forms of communication. This is done not only in the science-specific sessions (as with the morning sessions we conduct at camp), but also in the recreation-related free choice sessions; for example, campers make observations and inferences about the science (physics) and math concepts involved in tacking while sailing, describe their observations while snorkeling a shipwreck, inquire and wonder about the unique species observed at aquatic features of natural areas, and consider/discuss human impacts on sensitive conservation areas.

*Strand 4: Learners reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena (NRC 2009, p.7).*

The Camp schedule provides time with mentors to reflect, and structures end-of-the-day campfires with a reflective mood and purpose to consider the campers' learning throughout the day.

*Strand 6: Learners think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science (NRC 2009, p.7).*

Camp allows learners to identify with the Great Lakes bioregion and the scientific enterprise. The pre- and post-surveys prompt campers to think about themselves as science learners. The program invites many types of aquatic resource professionals, persons with avocational interests in water resources, and diverse (gender, racial/ethnic, age) mentors that appeal to diverse campers with varied interests.

Having youth learn that there is a place for them in the "scientific enterprise," whether or not they eventually choose a career in science, is an important program objective, addressed through our diverse, mentoring staff of researchers, counselors, and educators Water science fields need all sorts of professionals and citizen-leaders with familiarity with aquatic resource sciences in all walks of life – as community opinion leaders, as informed consumers, as neighbors, as civic volunteers working in our libraries (and not only our conservation groups), and most of all, as political leaders.

Finally, nonformal water science education programmers should remember to make mindful and intentional decisions about program philosophy and approach. We have chosen to work through the lens of Place-Based Education, and to base our work on the research within environmental

education realms. In this way, our nonformal camp program is positioned to support the wide-ranging initiatives of others working from these lenses, and to foster a large "ripple" in the world of science education.

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# One World One Water Center for Urban Water Education and Stewardship

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**Abstract:** The One World One Water Center for Urban Water Education and Stewardship (O'WOW Center) at Metropolitan State University of Denver is an innovative program designed to educate students and others about the important role of water in Colorado's economy and environment. The Center was created in 2011 with a $1 million donation to develop "urban water stewards" from diverse backgrounds and a wide range of disciplines. Students who study hydrology, history, politics, biology, water law, psychology, theater, art, geography, environmental science, chemistry, conflict resolution and negotiation, and other disciplines will be guided toward internships, careers, and volunteer opportunities to help shape new solutions for local and statewide water issues. To date, approximately 6,000 people have been directly reached by the O'WOW Center during the first four years of operation with potentially thousands of others reached indirectly. Outreach activities have included water festivals, water summits, author talks, seminars, media events and field trips. This paper illustrates the need for the O'WOW Center and presents information regarding MSU Denver, the Pilot Project and how the Center was created. The new Water Studies minor and Water Studies Certificate, fundraising and other current projects of O'WOW are described. Finally, the paper explores successes and challenges experienced by the faculty and staff of the O'WOW Center.

**Keywords:** *OWOW, water education, water minor, Denver, Metropolitan State*

Water is a central issue in Colorado, home to the headwaters of five primary river systems – the Arkansas, Colorado, South Platte, Rio Grande and White/Yampa. However, this resource is being threatened on many fronts:

***Population Growth***. Colorado's population is expected to increase by 1.4 million, or 25 percent, by 2030 (Colorado Water Conservation Board 2010).

***Climate Change***. Currently, 80 percent of Colorado's surface water supply originates as snow. A predicted 2.5-degree temperature increase by 2025, and 4-degree increase by 2050, could mean less snow in the Rocky Mountains, or an earlier springtime runoff. Warmer temperatures would require Colorado to adopt long-term strategies for using and sharing water among competing constituencies. Hydrologic forecasts predict protracted drought in the Southwest imposing ever greater demands on an already over-allocated Colorado River (Colorado Water Conservation Board 2015).

***Resource Management Conflicts.*** The Colorado, South Platte, Arkansas and Rio Grande Rivers originate in Colorado and supply water to 19 Western states. Interstate compacts require that Colorado allow significant amounts of water to leave the state for downstream uses. In addition, four major groundwater aquifers supply Colorado, and 18 percent of the state's total water supply comes from groundwater,

portions of which are being rapidly depleted (Colorado Watershed Assembly 2015).

***Economic Shifts***. Early water-use regulation was created in the 1800s primarily for agriculture and mining. Newer industries including energy development, tourism and recreation also depend on water, and are very prominent in Colorado's economy. Much of the state's growing population is calling for changes in the water management system, while those who depend on senior water rights insist on preservation of the centuries-old system of water allocation.

***Environmental Protection***. Almost 850,000 lbs of toxic chemicals from industrial sources were deposited into Colorado waterways in recent years. Acid mine drainage dating back to the heyday of Colorado's mining industry affects more than 1,300 miles of streams. Debate continues regarding the water quality impacts of runoff from irrigation sources (such as lawns, golf courses, and agriculture) and use of hydraulic fracturing fluids in oil and gas production. Additionally, proposed inter-basin water transfer projects require expensive capital investment and carry unknown long-term environmental costs (Denver Post, June 24, 2014).

Water stewardship and sustainability are clearly important and responsible education topics in Denver's urban environment. Metropolitan State University of Denver (MSU Denver), located on the Auraria Campus in downtown Denver, is uniquely positioned to offer a water curriculum that promotes water stewardship and sustainability for the region. MSU Denver is a large (>20,000 students) urban campus adjacent to a major headwater river, the South Platte. The institution educates a large percentage of underserved/ disadvantaged populations, and has the largest number of students of color of any institution in the state. Notably, MSU Denver has alumni who largely stay in Colorado and the Denver Metro area, thereby empowering and affecting change in our region. In addition, our urban university has as part of its mission, a mandate to help the public solve community-related issues such as water management.

Water both unites and divides our state and its varied regions and industries. Understanding this precious natural resource is critical to laying a foundation for economic development and stability, as well as for environmental protection. To address these concerns on campus, MSU Denver created the One World One Water Center for Urban Water Education and Stewardship (O'WOW Center). Through the O'WOW Center, students and communities learn how water issues intersect with important economic and environmental factors via in-class learning and participation in water-related community outreach efforts. These activities correspond to MSU Denver's "urban land grant mission" by helping to create an educated, empowered, solution-oriented, Colorado citizenry that protects and preserves our water resources. Water use and management have played a fundamental role in Colorado history and will continue to shape our future. The mission of the One World One Water Center for Urban Water Education and Stewardship is to transform our community's knowledge of and encourage active participation in Colorado's critical water issues.

One of the first accomplishments of the O'WOW Center was the creation of a Water Studies minor for all academic majors at the university, accompanied by extra-curricular and community activities. The distinctiveness of the minor and the additional activities is that they focus on creating water stewards and not simply water scientists, lawyers, engineers or other stereotypical career paths for those interested in water. The classes and activities focus on the tough issues facing water users in the West, such as water shortages, population growth, conflicting water management efforts, public education, and outreach. O'WOW curricula and programs are designed to create water stewards regardless of major or selected career.

## O'WOW Center Development

The project began during the fall of 2010 when MSU Denver was challenged to develop the concept of what water education could look like for the university as a condition of a gift of the bronze, One World, One Water sculpture (See Figure 1). Research on current efforts at Colorado State University, the University of Colorado, and




Figure 1. "One World, One Water," a bronze by Rik Sargent, is located in front of the Student Success Building at Metropolitan State University in Denver.

the University of Denver indicated that an "urban" focus on water resources education was needed. In addition, it became clear that students in the arts and humanities needed opportunities to participate as well, since not all water issues are purely science, legal or policy oriented. This ultimately led to the creation of water-related courses and activities in all colleges at MSU Denver – College of Professional Studies, College of Letters, Arts & Sciences, College of Business, and the School of Education. The work was facilitated by an anonymous gift of $1 million over a five-year period.

Development of the funding criteria, course development strategy, and student marketing requirements occurred during the first half of 2011. Funds were earmarked for staff salaries, office space, on- and off-campus events, training, course development, and student scholarships. This process occurred in collaboration with a university-wide advisory group that included faculty from Earth & Atmospheric Sciences, Business, Industrial Design, Art, History, Deans from the Colleges of Professional Studies, Business, and Letters, Arts & Sciences, and the Provost.

The cornerstone of the campus outreach, and impetus for the program, is Rik Sargent's bronze called One World, One Water. The O'WOW Center installed and dedicated the One World, One Water sculpture at a campus entryway in front of MSU Denver's new Student Success Building. Engraved in the entryway walkway are numerous quotes about the value of water, reminders literally set in concrete to bring awareness about the topic of water. The sculpture was donated by local philanthropist, Valerie Gates. It is a 3000-pound, 12-foot-high, 8-foot-deep, 10-foot-wide educational sculpture in an infinity form shaped as a single drop of water, weaving together watersheds and eco-systems (See Figure 1). It was designed by the sculptor as a unity symbol, combining art, science and education, and honors water education at MSU Denver and around the world. The National Sculpture Society, the oldest organization of professional sculptors in the United States, accepted One World, One Water into its annual juried show in 2012. A 24-inch maquette traveled across the eastern United States, representing the piece.

The MSU institutional mission statement, "Transforming Lives," was our guiding principle as we developed the Vision and Mission Statements for the O'WOW Center. This led to development of a Strategic Five-Year Plan which identified goals and objectives, fundraising targets, student recruitment, and community outreach. It was important that these efforts were inclusive, collaborative, and sustainable. According to Hinton,

> *The impact of institutional culture on strategic planning cannot be overestimated. In fact, if you gave the same strategic plan to ten different institutions, those institutions would each interpret the plan differently and develop ten different implementation plans. These differences are usually the result of at least three critical factors: the institution's unique environment (including the institutional mission and history of the organization); the structure and competence of the administrative staff of the institution; and, the development of staff commitment to planning* (Hinton 2012, 23).

This observation was apparent throughout our strategic planning process in that the "culture" of MSU Denver was embedded within the final goals and objectives. "Transforming Lives" meant providing opportunities for students to have access to relevant water-related courses on campus, to identify and provide meaningful internships in water-related professions, and to allow our students to have a voice in water policy conversations. This has occurred numerous times through hosting of state water plan meetings on campus, linking students with internships at local, state and federal water agencies, and providing opportunities for students to voice their opinions and perspectives in relevant water conversations across the state.

The donor agreement was signed in August 2011, and a program director was hired in December 2011. Work began in earnest at that time, and with the hiring of a half-time Assistant Director in February 2012, water-related events on campus flourished. Course development and creation of the pilot Water Studies minor occurred during the winter and spring of 2012, and the first water courses for the minor were offered during fall semester of 2012.

The One World One Water Center was created and housed within the College of Professional Studies at MSU Denver, and not placed within an academic department. There were several reasons for this organizational placement at the university. First, it was vital that the O'WOW Center was not perceived as focusing on only one academic program at the university, i.e., Earth Sciences or Political Policy or Pre-Law. It was important that all faculty and students felt included in the outreach of the program, and that the O'WOW Center was not strictly a one-dimensional academic unit.

Second, having the O'WOW Center as a separate entity at the university provided vast opportunities for dialogue, engagement and collaboration. Part of the challenge (and success) of the program was creating interest in and support for the new effort toward water stewardship education on campus with faculty and administrators. As with many other colleges or universities, new programs too often come and go, but the focus on water was an intriguing and widely supported topic of conversation and engagement at MSU Denver.

Third, it has been critical to have the Dean of the College of Professional Studies as the leader of this effort to help converge and connect with other academic and administrative units at the university. Academic institutions, by nature, are often silo-encased, rigidly administered institutions which can hinder cross-department (both academic and administrative) collaboration. It was vital to have the O'WOW Center part of the College of Professional Studies, with the Director reporting directly to the College Dean, Dr. Sandra Haynes. This provided a passionate internal advocate to open doors to various administrative departments on campus, as well as high level access to other Deans, Vice-Presidents, and the Provost's Office at MSU Denver.

As alluded, the Center has three major functions designed to deepen students' understanding of water as a critical resource that must be sustained and conserved for all:

1. To offer an interdisciplinary Water Studies minor to complement a wide variety of majors.
2. To provide enriching co-curricular activities.
3. To enhance water stewardship on and beyond campus by promoting experiential opportunities on and beyond the Auraria Campus.

Thus, the O'WOW Center has formal, curricular, and informal, co- and extra-curricular, education components. The enriching co-curricular activities and experiential opportunities were included to provide real world, hands-on settings for students to apply knowledge obtained in the classroom. These methods of learning are widely accepted and encouraged since "the importance of promoting retention of college students lies not merely in maintaining their numbers for the sake of retention statistics, but more in providing students with value-added experiences that will benefit them upon their leaving college." (Tan et al. 2015, 2). These components were developed by the university-wide advisory group described above. Early on, it was determined that a Water Studies minor at MSU Denver would be the primary way to create water stewards on and beyond the campus, and will be described in more detail below.

## Formal Education

### The Water Studies Minor

Although some courses in water were taught at MSU Denver prior to the implementation of the Water Studies minor, they were relegated to specific departments such as Earth and Atmospheric Sciences, Biology, and Chemistry and no degree programs existed in water-related areas. An 18-credit hour curriculum was developed – with input from faculty familiar with water studies topics and an industry advisory council – to facilitate education of students from a wide range of disciplines including sciences, humanities, arts, and professional. The Water Studies minor includes three core courses: Water Essentials, Colorado Water Law and Water Rights Administration, and Water Conflict: Applied Leadership Communication.

It was widely agreed that a basic "Water 101" course would be needed to introduce the topic of water to students not familiar with the topic. A faculty member from the Department of Earth and Atmospheric Sciences offered to create "Water Essentials", a freshman-sophomore level introductory water class that covers topics of ancient water history, surface and groundwater hydrology, water quality, irrigation and municipal water uses, dams, water law, environmental issues, conservation, wastewater treatment, and future conflicts – from Colorado, U.S. and world perspectives.

The second core course is "Colorado Water Law and Water Rights Administration." Colorado has the most legally rigid method of water administration in the U.S., and must be understood by water stewards if they are effectively going to understand and engage in water resources issues and opportunities. The course is taught by a practicing water attorney, but is geared for non-technical students. It is hugely popular with class participants.

The third core course, "Water Conflict: Applied Leadership Communication," is in the Department of Communications Arts and Sciences. The advisory group determined there was a need for a core class in water conflict resolution, since conflict over water is common in Colorado and the West. We were not aware of a similar class like this at other universities, so it was identified as a great opportunity to develop an innovative course for the new Water Studies minor.

To complete the minor, two other elective courses selected from water-related courses from departments across campus are required, as well as completion of a senior internship or capstone project. The electives include, for example, land use and water quality courses in the Earth & Atmospheric Sciences Department, senior seminar course in the Theatre Department, survey and marketing class in the Business College, and a social documentary course in the Journalism Department. Academic majors showing initial interest are Geography, Environmental Science, Biology, Earth Sciences, Psychology, English, Industrial Design, Anthropology, Sociology, Teacher Education, History, Business, Art, and even Theatre. Faculty from across the MSU Denver campus offer water-related courses in disciplines including Earth and Atmospheric Sciences, Environmental Science, Management, Journalism, Industrial Design, Women's Studies, the Arts and more. Students gain an understanding of the importance of water and how to integrate that focus within other academic and career interests.

Internship work occurs generally at a water resources organization or agency, but many non-profits (involved in environmental protection, water quality, and water policy) have provided internships for students in the Water Studies minor. Internships follow a prescribed syllabus with specific learning objectives. The internship requirement has been a popular and very important part of the Water Studies minor for several reasons. Internships have provided students with real world experiences in areas of water resources. The experience has helped some students begin their careers after graduation at these same water industries, and in a few cases has exposed students to other areas of water resources not considered previously.

The internships have generated much interest with water-related groups in the area, and have allowed the O'WOW Center to partner with these groups on other collaboration opportunities – such as class and lunch speakers on campus, partnering on field trips, funding for water-related programs

on and off campus, and helping to identify industry needs of recent graduates. Internships are a major resource for helping students find entry-level jobs in water resources (Korn 2013).

Capstone projects could be performed individually or by a team, and are identified through collaboration of an academic department and the O'WOW Center. Students must have a faculty advisor for a capstone project, and learning goals are determined by the faculty and the academic department. Projects can be done individually or in a group, determined by the nature of the project. A goal is to include industry in the selection of a capstone project, as well as the growing undergraduate research program at MSU Denver. The value of capstone projects cannot be over emphasized. "Companies report that 69 percent of summer interns who applied for full-time positions received offers, according to a recent survey from the Graduate Management Admission Council, with even higher conversion rates in consulting, finance and accounting" (Edgar et al. 2011, 21).

Electives are selected with assistance and approval from the O'WOW Center staff or from the student's academic department major. A partial list of classes are provided to students, although a very wide range of courses can be utilized as an elective, depending upon the student's major.

### Water Studies Certificate

A Water Studies Certificate was created in Fall of 2015 to provide opportunities for students to complete the same program of study as the Water Studies minor. The certificate program allows a student to "double count" courses for their non-water academic major or minor and the Water Studies Certificate; this is typically not allowed for a major and minor. Many students were very interested in completing the Water Studies minor, but learned about the program too near graduation to take the extra courses or were in declared majors that overlapped with the Water Studies electives. The certificate will allow these students to complete the program of study while still graduating on schedule. In addition, the certificate can be taken by non-degree seeking students – a popular idea with working water professionals and others who are interested in gaining a broader perspective of water resources issues.

## Informal Education

### Providing enriching co-curricular activities

Water Studies students are encouraged, but not required, to engage in a variety of optional activities on and beyond the Auraria Campus in downtown Denver. Students have created the Water Association of Student Stewards Urban Program (WASSUP) Club, and meet several times each month to plan and participate in activities such as Lunch and Learn events, cleanup of nearby Cherry Creek, tours of water-related facilities in Denver and along the Front Range of Colorado, and to host speakers on campus. It is important that students engage in "real life" impacts of water resources in Colorado via conversations with those stakeholders directly affected by and involved with water policy. Face-to-face meetings are essential for students to facilitate their understanding of the issues and to practice conflict resolution skills.

### Enhancing water stewardship on and beyond campus by promoting effective use of water resources

The creation of the O'WOW Center has helped immerse MSU Denver students in water issues, and also creates visibility and education about water stewardship for the students at the Community College of Denver and the University of Colorado, Denver, who also share the Auraria Campus. Students have adopted a one-mile reach of Cherry Creek (located near the campus) and conduct semi-monthly trash clean-up efforts facilitated by the student water club and the Department of Earth and Atmospheric Sciences at MSU Denver. In addition, students have assisted with note-taking at state water planning meetings, conducted campus-wide water audits, and have given presentations to small groups regarding the state water plan and its implications for future population growth in the region. In addition, students have participated in a wide range of internships off campus – ranging from summer positions at Trout Unlimited and the Colorado Water Trust, to state agency work at the Colorado Department of Public Health and Environment, and the Colorado Archives. Each experience has provided students with a broader understanding of water resources issues in Colorado, the ability

to contribute toward water stewardship efforts of various organizations, and allowed students to engage in broader discussions on water in the state.

## Advisory Council

An important part of community engagement was the establishment of the O'WOW Center Advisory Council (21 members). The council is comprised of leaders in water from around the state. The board is designed to advise on curriculum issues, assist with community outreach, and with fundraising. Through the advisory council and other efforts, the O'WOW Center has established partnerships/relationships with key people in the water community including water representatives from the Colorado Water Conservation Board, Colorado Foundation for Water Education, Denver Botanic Gardens, Tri-County Water Agency, Colorado Water Institute, Colorado Water Archives at Colorado State University, Colorado Water Congress, Nuestro Rio, U.S. Bureau of Reclamation, Denver Water, Colorado Department of Public Health and the Environment, Aurora Water, City of Boulder, Colorado Water 2012 Committee, the Greenway Foundation, History Colorado, Project WET trainers in Colorado, South Metro Water Authority, American Water Works Association, American Water Resources Association, Central Colorado Water Conservancy District, and the Colorado Archives. With these relationships, the O'WOW Center has developed internships, funding opportunities, and other partnerships with some of the most important agencies in water in the state.

## Current Status

The project is in its fourth year of implementation and has already made a tangible impact on the campus and region. The Water Studies minor courses at MSU Denver have over 100 students currently enrolled, and are providing a great resource for students to learn more about water in the region, discover career opportunities, and to become water stewards. Over 50 students have signed up for the two-year old Water Studies minor, and 12 students have graduated with the minor.

The O'WOW Center has provided many co-curricular enrichment activities for the entire Auraria Campus. Hosting water-related authors as guest speakers has generated the most interest, with over 100 people attending each of these events. Classroom speakers provide the next best forum, and numbers range from 20-30 students in attendance. Topical speakers (water managers, climate experts, etc.) can have a wide range of participation depending upon time/day of week, placement during the semester, and even weather, and has ranged from 10-30 students in attendance. Internships have also been a popular method of engagement for students, and to-date over 25 students have worked at water-related organizations in the area in the past two years.

The library on campus serves MSU Denver, the University of Colorado, Denver, and the Community College of Denver, as well as visitors. It is an ideal location for permanent and non-permanent education materials. Working with the Director of the Auraria Library, the O'WOW Center helped place a large digital display system (called the Discovery Wall) in the library to include interviews, TED talks, information on the new Water Studies minor, water news, short features, and other presentations. The Center also places banners, brochures, water-topic books, and other water-related items in the library.

The O'WOW Center placed banners in the Tivoli Student Union, Science Classroom Building, Administration Building, and other appropriate locations on campus and has worked with the on-campus coffee shop to place table tents offering free coffee to "like" the O'WOW Center's Facebook page. Additionally, the O'WOW Center has a dedicated webpage and social media presence via Facebook, Twitter, and Instagram.

Community engagement occurs both on and off campus, and occurs through the support and through the coordination of the O'WOW Center. Numerous speaking events, open to both students and the community, have been sponsored by the O'WOW Center including Brad Udall, Western Water Assessment, Carly Jerla, U.S. Bureau of Reclamation, Jorge Figureroa, Western Resource Advocates, authors Paolo Bacigalupi and Kevin Fedarko, and acequia expert Dr. Devon Pena.

These and other speakers presented on topics as diverse as fracking, acequias (Spanish irrigation systems), global climate change, Colorado's state water plan, endangered whooping crane migration, and water careers. MSU Denver was very pleased to be the first university to host the Metro Water Basin Roundtable annual meeting – a water resources information/planning event for the Denver metro region which brought about 80 people to the campus.

Co-curricular activities hosted by the O'WOW Center are sometimes limited to students, but are often open to the public. Field trips that provide hands on learning are an important part of the O'WOW Center. Field trips have been conducted in the following locations:

- Colorado River on the western slope of Colorado to view irrigation diversion structures, visit an organic irrigated farm, and to learn about crop production issues;
- San Luis, Colorado, for a class from the Department of Chicana/o Studies, to learn about acequia irrigation systems;
- Central Nebraska for a photo journalism class to view the Sandhill crane migration and to write magazine-style articles regarding their perceptions of the migration;
- A water diplomat program in downtown Denver for university students from across Colorado.

Each of these field trips included 10-30 students, and provided students with opportunities to visit with local water managers, learn about local water issues, and see first-hand the complexities of water management in semi-arid regions of the U.S.

The Center provided an O'WOW Center Award of $100 at the Undergraduate Research Conference at MSU Denver for the best water-related research to encourage participation in water education across campus and support high-impact educational practices. A similar award was also provided for the annual MSU Denver speech competition called the "Spectacular Vernacular." Last year 12 students (primarily Speech majors) developed persuasive and/or informative speeches related to the topic of water, and successfully engaged a new academic department with the topic of water.

MSU Denver has a unique decision theater called the Center for Advanced Visualization and Experiential Analysis (CAVEA). The purpose of a decision theater is to visually display data in a variety of formats to assist participants with a decision making process. CAVEA combines a multi-room facility, with advanced technology to support users in making better decisions through visualization and collaborative problem-solving. It will be used for a variety of water resources efforts with students, faculty, and regional water agencies. The O'WOW Center and the CAVEA Director are presently working with the Colorado Water Conservation Board to assess various data-driven scenarios, such as watershed restoration issues, population growth and water supply alternatives, and impaired water quality locations, for improved water management on the South Platte River and other river basins across Colorado. The CAVEA will allow stakeholders to view complex data sets as overlays on land use maps, within geologic formations, through time lapse photography, and a host of other visual applications. Two adjacent breakout rooms can be used by groups to reevaluate legal or policy positions to seek compromise on contentious water resource issues. A facilitator would also be engaged for such situations. Water policy experts and water resources planners would benefit greatly from this discussion, and scenarios developed through this process could be used by river basin planning roundtables located throughout Colorado.

In 2014, the Center organized, hosted, and sponsored the first ever University Water Festival on campus. Over 800 middle school students and their teachers participated, and exhibitors included Denver Water, Central Colorado Water Conservancy District, Northern Colorado Water Conservancy District, Aurora Water, Denver Zoo, O'WOW Center, Auraria Library.

The Center helped coordinate and assisted with Roadrunners Give Back/Comcast Cares/ Greenway Foundation Volunteer Day. This day was organized by campus in conjunction with two community organizations to clean up around campus and several miles along the South Platter River. Our proximity to the river (located just a

block from campus) provides opportunities for collaboration with groups such as the Colorado Foundation for Water Education Urban Bike Tours along the South Platte. These tours provide valuable hands-on education experiences regarding specific urban water resource issues.

The O'WOW Center has also worked with the Auraria Higher Education Corporation (AHEC) to create an edible garden on campus, and hosted a "Wine & Water" event with the Colorado Supreme Court Library and the University of Denver. Other examples of collaboration included hosting discussions of ancient water systems such as Machu Picchu, organizing a "Water and the Arts" event in 2013, helping to organize "Family Water History" events with History Colorado, and hosting the French Consulate's seminar on Climate Change and Public Health on campus in June 2015.

## Conclusion

Seven new courses have been developed for the Water Studies minor. The One World, One Water sculpture was installed and dedicated at a campus entryway in front of MSU Denver's new Student Success Building. A dedicated website and social media outlets have been developed. Numerous water-related events have been held on the Auraria Campus. Many student internships have been completed, and recent graduates are beginning careers in water resources fields.

The following valuable lessons have been learned during this pilot process, and have been identified through formal and informal assessments:

1. University administration support has been essential to the development of the O'WOW Center, and will continue to be crucial to its success. The donor provided $1M over five years to start the project, but the University Board of Trustees, through the support of the President, also provided over $400,000 over that same time period. The Provost's Office, College Deans, and various administrative department leaders have all provided assistance with student outreach, assistance in curriculum development – and in many cases financial support. These university-wide efforts helped encourage students to register for the water studies classes, assisted the O'WOW staff in navigating the complex issues related to curriculum approval processes, academic advising challenges, and greater engagement of faculty members – generally the gate keepers of student engagement.
2. Hiring people who have experience with water education, higher education, and the water community is crucial to O'WOW outreach efforts. O'WOW staff and administration must be "connectors," and have a passion for water education, students, and other faculty and staff. Without employees interested in establishing connections among water professionals and the campus community, the number of internships offered and grants secured thus far would have been impossible (Pertuze et al. 2010).
3. Marketing to students and the community requires person-to-person contact, good relationships with faculty, and coordination with career services, academic advisors, and recruiters off campus. MSU Denver is a commuter campus, with most of the 22,000 undergraduate students traveling to campus by car, bus and light rail. In addition, 89 percent of the students work part- or full-time, and many have families (the average age of students is 25). Therefore, connecting and engaging students has been a major challenge, and it has been found that most students learn of the O'WOW Center and the Water Studies minor through classroom presentations and recommendations from academic advisors. Positive relationships and awareness building, with faculty and advisors, has played a major role in student recruitment. This has been confirmed through informal surveys of students and faculty regarding how they heard of the O'WOW Center, and what methods of program information delivery works best for them.
4. In order to keep students engaged it is important to show them how the new minor can help with future job opportunities. One

of the very first questions that students ask about the Water Studies minor is "What types of jobs will be available if I take these courses?" Water career information is not readily available to many students, possibly because students do not conduct enough individual research, or perhaps because the water community does not have strong connections with undergraduate students who are seeking careers in non-scientific disciplines. Connecting and engaging students and future employers has been a rewarding aspect of this program, generally through internships and entry-level job opportunities. An example is a psychology major with an interest in behavioral change toward water conservation. She worked at a water trust organization to change perceptions toward environmental protection.

5. Selection of a high profile industry and community advisory council is important because they can provide invaluable connections, perspectives, and insight sometimes overlooked by educational efforts. The advisory council initially met face-to-face four times per year, and now has created a committee structure to reduce meetings to twice annually. Separate committees take responsibility for the areas of internships, fundraising, student success surveys, and off-campus programming activities. This assistance is critical to add credibility to a new program, and identify potential collaborations. Other areas of support were identification of internships, fundraising opportunities, and recommendations regarding implementation of the strategic plan and attention to "mission creep."

A significant element of the O'WOW Center's programs is "How is it relevant to the needs of the water community?" Are we teaching the proper courses, providing appropriate field trip opportunities, and connecting students with internships that help them find fulfilling careers, and to become water stewards? This will be determined by placement of graduates, involvement in local water issues, general improved awareness of water issues in the region, and the extent of involvement in voluntary and non-profit water related activities. This will be measured by alumni and water industry surveys (created by our Advisory Council), review of core curriculum content by members of the water/environmental community, and continuous outreach and feedback from current and potential employers.

According to MIT Sloan Management Review, best practices for creating university/industry partnerships include:

- Building strong communication linkage with the university team.
- Building broad awareness of the project within the company (industry)
- Investing in long-term relationships
- Selecting boundary spanning project managers (Pertuze et al. 2010)

In retrospect, connecting industry leaders sooner with faculty members could have paid more immediate dividends (in terms of internships and undergraduate research opportunities). However, building relationships takes time, and rushing into partnerships is not necessarily a wise move. Concurrently, the O'WOW Center staff could have spent more time recruiting students into the Water Studies minor, to the detriment of other phases of the program. However, the Water Studies courses must prove relevant and worthwhile to be attractive to undecided students. The challenge has been where best to focus the time and energy of only two full-time staff members.

Each institution is unique, and new programs will be developed to fit the needs and culture of the organization. The One World One World Center at MSU Denver has benefited greatly by following the best practices described above, having a very supportive faculty and administration on campus, and engaging industry in program development.

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## Author Bio and Contact Information

**Sandra D. Haynes, Ph.D,** has served as Dean of the College of Professional Studies of Metropolitan State University of Denver since 2003. Haynes's collaborative

approach helped obtain approval for a new Hotel and Hotel Learning Center, athletics complex, and Aerospace Engineering Sciences Building. Dr. Haynes helped secure a $9.5 million Teacher Quality Enhancement Grant, and a $3.8 million Title III Grant to improve advising college-wide and establish a School of Education. Haynes was the primary person responsible for obtaining the "One World, One Water" sculpture and the $1 million grant to create the Water Studies program. She was a 2010-11 American Council on Education Fellow, received the 2009 Metro State President's Award for Distinguished Service, and 2004 Outstanding Woman's Award for the Advancement of Education for Woman. In 2014, Haynes was awarded an honorary doctorate and professorship by the University of Pecs in Hungary for her work in developing international partnerships. Dr. Haynes may be reached at hayness@msudenver.edu.

**Tom Cech** was born and raised on a farm near Clarkson, Nebraska, graduated from Kearney State College with a Bachelor of Science Degree in Math Education, and later received a Master's Degree in Community and Regional Planning from the University of Nebraska, Lincoln. He was Executive Director of the Central Colorado Water Conservancy District in Greeley, taught undergraduate and graduate level water resources courses at the University of Northern Colorado and Colorado State University, and is now the Director of the One World One Water (O'WOW) Center for Urban Water Education and Stewardship at Metropolitan State University of Denver. Tom wrote *Principles of Water Resources: History, Development, Management and Policy*, published by John Wiley & Sons – currently in its 3rd edition. Tom also published *Introduction to Water Resources and Environmental Issues,* (co-author Dr. Karrie Pennington) with Cambridge University Press, and *Colorado Water Law for Non-Lawyers*, (co-author P. Andrew Jones) with the University Press of Colorado. He may be contacted at tcech@msudenver.edu.

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# Water Quality and Nutrient Management Extension Programs in Ohio

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**Abstract:** Extension has a long history of conducting educational programs for agricultural producers on a wide array of issues, including water quality. In Ohio, the focus of these educational efforts has grown to include best management practices for nutrient management. The need for education in nutrient management began in earnest in the 1970s due to the presence of harmful algal blooms (HAB) in the Western Lake Erie Basin. International actions taken during that time all but eliminated the HABs from the lake until they made a resurgence in the 1990s. Twenty years later, the HAB threat in Lake Erie is still present and has major implications for commerce, tourism, and human and environmental health. The HAB threat has spurred outcries from the general public, resulting in the creation of new laws by the Ohio Legislature, and an expanded and enhanced focus area for Ohio State University Extension (OSUE) programming. In this paper, we describe the conditions that have led to the development of the HAB in Lake Erie, the legislative action that has been taken in attempts to curb the problem, and the educational programs developed by OSUE in partnership with state agencies, non-government organizations, and other interested parties to address these water quality issues with Ohio agricultural producers and the general public.

**Keywords:** *Lake Erie, Harmful Algal Blooms (HAB), microcsystin, phosphorus, nitrogen, Ohio, extension*

Lake Erie is the shallowest, smallest by volume, and southernmost of the Laurentian Great Lakes (Millie et al. 2009). The lake is bounded by the Canadian Province of Ontario to the north and the US States of Michigan to the west, and Ohio, Pennsylvania and New York to the south and east. As with all the Great Lakes, Lake Erie is a vital source of drinking water, international and interstate commerce, recreation, tourism, and industry for the nearly 12 million residents living near the lake. Because of its relatively small size and shallow depth, Lake Erie is more susceptible to disturbance due to natural and human influences than the other Great Lakes (Millie et al. 2009).

The lake has experienced significant nutrient loading, especially phosphorus, from a number of point and non-point sources for most of the 20th century. Excessive loading of nutrients in agricultural run-off has long been associated with a myriad of water quality issues around the world, including the Great Lakes region (Makarewicz 1993). In the Great Lakes region, Lake Erie has consistently been the most affected by excessive nutrient loading (Baker 1985) with excessive phosphorus and nitrogen in run-off waters cited as the most damaging (Forster and Rausch, 2002; Richards et al. 2013). Since phosphorus is the primary limiting nutrient for harmful algal bloom (HAB) development, the cumulative addition of phosphorus over time has enhanced the development of HABs and significantly impaired the water quality of the lake (Bertram 1993; Taft 1945). HABs create taste and odor problems

within the water, degrade overall environmental quality, and make the lake less aesthetically pleasing. In addition, certain HAB species release toxins in the water, which pose a significant health hazard to humans and wildlife (Dove and Chapra 2015).

To address these issues, an international commission was formed in the 1970s to develop and implement strategies for reducing nutrient loading in the lake. These strategies included upgrading municipal water treatment systems, reducing the phosphorus content of soaps, detergents, and lawn fertilizers, and promoting agricultural practices that reduced tillage and increased residue cover. These actions resulted in a decrease in phosphorus runoff into Lake Erie, and for a time, a cessation of HAB formation (Chesters et al. 1980).

HABs appeared again in Lake Erie in the 1990s. Causes cited for this resurgence included increased nutrient loading from point and non-point sources, and a warming of the lake (Baker 1992; Millie et al. 2009). Zebra and quagga mussels (*Dreissena polymorpha* and *D. rostriformis bugensis*) were also found in Lake Erie during this time. These mussels are non-native invasive species brought into Lake Erie through the ballast of ocean going ships. These invasive mussels have caused numerous environmental problems in the Lake, including changes in the trophic structure of the lake and a clarification of the water column (Holland 1993). This clarification is allowing sunlight to penetrate deeper, and is believed to be contributing to the resurgence of HABs (Wynne et al. 2010).

HABs are scums of green algae which form on the surface to a depth of 2-3 feet and can produce the toxin microcsystin. When present in large enough quantities, microcsystin can cause significant human and environmental health problems (Millie et al. 2009). 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). The potential damage HABs can cause was highlighted on August 4, 2014. On this date, the close proximity of HABs to the city of Toledo water intake facilities resulted in microcsystin levels exceeding the 1 ppm threshold for safe drinking water set by the U.S. Environmental Protection Agency. This threshold, combined with the outdated city water intake and treatment system, shutdown Toledo's water supply to over 400,000 residents. This shutdown lasted for 50 hours, and drew the world's attention to the water quality problems in Lake Erie, and by extension the entire Great Lakes basin, like no other event. Public outcry concerning the presence of HABs and their perceived causes have been increasing over time, and reached a crescendo with the Toledo water crisis (Richards et al. 2002).

## Legislative Response

The Ohio Legislature, in response to increased pressure from the public and the federal government, passed legislation in 2014 and 2015 in an attempt to reduce the causes and subsequent severity of the HABs.

In the fall of 2013, legislation was crafted to reduce nutrient inputs into Ohio's waterways. Senate Bill 150 was passed in the spring of 2014, and went into effect on August 22 of the same year. The bill mandates that agricultural producers who apply fertilizer to 50 or more acres of agricultural crop production be certified and keep records of all fertilizer applications. The law created a fertilizer applicator certification program to educate producers on the time, place, form, amount, handling and application of fertilizer along with the impact of nutrient loss on water quality. The bill serves as a component of a state level nutrient reduction strategy addressing all sources of relevant nutrients, and supports generally practical and economically feasible best management practices. The goal of this certification is to provide agricultural producers with a fundamental understanding of soil and fertilizer interactions and related best management practices to help them apply fertilizers in a more judicious manner.

The Ohio Department of Agriculture (ODA) was tasked by the legislature with implementing SB 150. ODA in turn contracted with OSUE to develop what has become Fertilizer Applicator Certification Training (FACT). FACT was scheduled to begin in December of 2014 in conjunction with Pesticide Applicator Training (PAT). Producers will have until September 30, 2017 to obtain certification. After the initial

certification, producers will be required to attend a two-hour recertification program every three years. OSUE will be the exclusive provider of certification training through the first three-year cycle. As per SB 150, this first round of FACT training will be conducted at no cost to those attending.

The Ohio Legislature in 2015 passed additional legislation in the form of Senate Bill 1. The intent of this legislation is to control algae production in the Western Lake Erie Basin through the regulation of phosphorus and nitrogen fertilizer along with manure applications. Under this law, a person may not apply fertilizer under the following conditions: 1) on snow-covered or frozen soil; 2) When the top two inches of soil are saturated from precipitation; or 3) when the local weather forecast for the application area contains greater than a 50% chance of precipitation exceeding one inch in a twelve-hour period. These rules don't apply if the fertilizer is injected into the ground, incorporated into the soil within 24 hours of application, or applied onto a growing crop. For manure applications, items one and two above apply. However, manure should not be applied when the 24-hour weather forecast exceeds 0.5 inches of rain in the application area. The law also requires that anyone applying manure from an ODA permitted animal facility to more than 50 acres in agricultural production be certified through the FACT program, or through the ODA Certified Livestock Manager Program. The effective date of this new law was July 3, 2015.

## OSU Response

Extension has a long history of conducting educational programs in the areas of nutrient management and water quality (Laughlin et al. 2004; Londo 2004; Vaughn 1989). Since one of the major land uses in Ohio is in agricultural production, it is appropriate that these educational programs have been focused on best management practices for nutrient management, soil drainage, and erosion reduction on agricultural lands (Christianson & Tyndall 2011; Richards et al. 2002). However, the current issues in Lake Erie have gone beyond traditional extension and research activities. To address the complex legislative, environmental, and general public concerns associated with Lake Erie, OSU developed an innovative and more comprehensive approach.

### Nutrient Management for Water Quality Signature Program

Signature programs are a cornerstone of the OSUE strategic plan. They are interdisciplinary in nature, including participation of all extension programming areas, are supported by focused marketing and promotion, and are replicable across the state. The Nutrient Stewardship for Cleaner Water Signature Program is designed to improve water quality by helping agricultural producers efficiently use nitrogen and phosphorus. By keeping more of these nutrients on the field, producers should experience increased crop yields, farm profits, and cleaner water. The signature program team is composed of county extension educators, field specialists, state specialists, and program coordinators from across OSUE. The programs conducted under the signature program include Fertilizer Applicator Certification Training (FACT), on-farm research, Certified Crop Adviser (CCA) training, and the manure science review. OSUE has also been part of a regional group that has developed a voluntary third party audit process for Nutrient Service Providers resulting in 4R Nutrient Stewardship Certified Facilities. Nutrient service providers are those that provide soil sampling, recommendation and application services to farmers. We just completed the first year of the signature program with another 2.5 years remaining. Evaluation of the program as a whole will be done through the summarization of the impacts of the component programs with a final report submitted to OSUE administration.

### FACT Training

Beginning in late spring of 2014, OSUE state and field specialists started developing the curriculum for the three-hour FACT training with significant input from county educators as well as OSUE pesticide safety educators. The FACT training was developed to meet the requirements set forth in Senate Bill 150. Given past experience in developing certification training programs, the pesticide safety education program was selected

to administer the FACT training program.

The curriculum modules are focused on four areas: understanding the certification process, water quality effects of N & P from agriculture, phosphorus management, and nitrogen management. In addition, yield response and cost information were tied together with water quality impacts to ensure agricultural sustainability. FACT products included presentations which were shared with county educators and program staff, plus a workbook for program participants containing exercises and material that could be reviewed at home. An evaluation tool and the Agricultural Fertilizer Applicator Certification Manual were developed to be used in training programs. The evaluation asked a number of typical extension program evaluation questions used for reporting purposes. In addition, there were also questions about producer awareness of the role of agriculture in the state's water quality issues. During 2014-2015, nearly 7,000 participants attended the FACT training programs held across the state.

Since FACT was conducted at the county level, a full-day in-service for OSUE county Agriculture and Natural Resources (ANR) educators was held in November of 2014. A goal of this in-service was to introduce the FACT curriculum, manual, and evaluation tool to the educators. In addition, the in-service provided an opportunity to ensure that county educators had the basic knowledge of soil science, fertility, and agronomy needed to conduct the training.

A de-centralized approach was taken to planning the FACT programs, with educators in each of the nine OSUE Extension Education and Research Areas (EERA) determining the number and timing of certification meetings for their area. The EERAs are geographically similar areas of the state containing 8-10 counties each. ANR Educators within each EERA work together to conduct a wide variety of training programs, including FACT. FACT programs were scheduled to begin in December of 2014; however, in response to the August water crisis in Toledo, trainings in the Western Lake Erie Basin started in September of 2014, three months ahead of schedule.

This training was provided on a county by county basis by local ANR educators and state and field specialists in agronomy and soil fertility. FACT training was conducted in conjunction with the annual Pesticide Applicator Training (PAT) held in each county. PAT is a three hour program, typically conducted in a county extension office. The cost for the three hour PAT training is $35 per person. Due to some similarities in training material, those who were renewing their PAT certification could take the FACT training for an additional two hours at no cost. Those without PAT certification were required to attend a three hour stand-alone session. Again, there was no charge for the 3 hour stand-alone programs. Funds to cover costs associated with conducting the FACT trainings were provided by the Ohio Department of Agriculture (ODA) and the Ohio Farm Bureau. Participant certification is provided by the ODA and is based on completion of the program only, no exam is required. Certification is valid for three years. Recertification requires two additional hours of approved continuing education credits obtained every three years. It is anticipated that recertification will also be free of charge.

First year results of the training from September 2014 through April 2015 show a total of 6,985 individuals were trained at 110 events held across Ohio. The largest concentration of participants was from NW Ohio counties in the Lake Erie Basin. Of all attendees, 2,074 program evaluations were collected immediately following the training, representing a 30% return rate. Most respondents reported they understood that most of the phosphorus entering the Lake Erie Basin is from agricultural operations, and that they need to be part of the solution. Future surveys will be distributed via email to determine longer term results of the FACT training. Of particular interest is a measure of behavior change in farmers. We want to know what steps have they taken, as a result of the training, to reduce nutrient loss from their land and the economic effects of those changes.

**On-Farm Research**

University based recommendations take into consideration production risk, input cost and off site concerns providing a foundation for farmers to invest in utilizing best management practices recommendations on their farm. Extension professionals have traditionally worked with farmers in their communities to adapt statewide

recommendations to local systems. Participating farmers have data they can use directly based on their operation and resources. These data can then be used more broadly to test the statewide recommendations in different environments.

Ohio nutrient recommendations are based on the joint efforts of The Ohio State University, Michigan State University, and Purdue University. The Tri-State Fertilizer Recommendations for Corn, Soybean, Wheat and Alfalfa Production were originally published in 1995. Small, on-farm research projects conducted throughout the years have improved these recommendations. Recent off-site concerns about nutrients, especially phosphorus in Lake Erie and nitrogen in the Gulf of Mexico, along with changes in crop production and weather conditions have led to a three year project beginning in 2015 to evaluate N, P and K recommendations for corn, soybean and wheat production. The project combines both small plot and on-farm evaluations of all three nutrients. Factors examined include application sources and rates, crop productivity, and nutrient content of water leaving these fields. These results will be used to evaluate the economic and environmental impacts of agricultural nutrient additions in the tri-state area. Ultimately, we hope to be able to help farmers better develop specific nutrient management strategies for their farms that maximize productivity and environmental benefits simultaneously. As appropriate, these results will also be used to update the tri-state recommendations.

**4R Nutrient Stewardship Certification**

The 4R Nutrient Stewardship Certification Program was developed out of discussions between agriculture retailers and non-governmental organizations in Northwest Ohio. The idea of the program was to acknowledge retailers applying best management practices in making nutrient rate, timing, placement, and source recommendations for their clientele. OSUE provided the expertise to ensure the guidelines developed for the 4R program were non-biased and science based, while still meeting the needs of individual farmers.

Through this program retailers prove, by means of a third party audit, that the following are included in recommendations and applications they make:

- Recommendations based on the tri-state nutrient guide.
- Consideration of all nutrient sources being applied to the field whether purchased through the nutrient stewardship program or brought into the operation such as organic materials.
- Recognition of sensitive areas when making recommendations and applications.

A total of 41 criteria are evaluated in the 3 year cycle of initial certification. The program is administered by the Ohio Agribusiness Association, with a governing body made up of the initial organizers. Plans exist to expand the program from the initial target areas of the Western Lake Erie Basin, which includes parts of Ohio, Indiana and Michigan, into the portion of Ohio that includes the Ohio River Watershed. Program criteria can be found at http://4rcertified.org/.

**Certified Crop Adviser Training**

An additional step OSUE has taken to deliver best management practices for the needs of northwest Ohio producers is to provide non-biased information and training to Certified Crop Advisers (CCA). The CCA program was initiated by the American Society of Agronomy (ASA) in 1992 to ensure that practicing agronomy professionals in the United States and Canada meet the professional standards established by the ASA. Certification requirements include an agronomy-related associate degree with three years of experience, a bachelor's degree in an agronomy-related field with two years of experience, or four years of experience with no degree. Once certified, 40 hours of continuing education every two years are required to maintain the certification.

One example of a CCA continuing education program focusing on nutrient management is the Conservation Tillage Conference (CTC). CTC is a two-day event held every March highlighting nutrient, soil, and water management topics for CCA continuing education credits. CTC is organized and taught by state and field specialists, county ANR educators, and state and federal agency collaborators. Annually, there are approximately 300-400 CCAs in attendance for the two day program. These CCAs consult on approximately 85% of Ohio's 14 million agronomic crop acres.

Evaluations collected at the conclusion of the conference indicate that the CCAs use the information they receive at the conference when developing cropping and fertilizer plans for their clients. Continuing educating programs such as this are essential train-the-trainer type events, allowing OSUE to expand the reach of our training efforts across many more acres than we could have ever done on our own.

**Manure Science Review**

OSUE conducts the Manure Science Review, an annual educational program, to share cutting-edge manure management information with livestock producers, CCAs, and certified livestock managers across Ohio. The event is held in a county location and rotated around the state each year to reach new audiences. The program consists of morning indoor educational sessions and afternoon field demonstrations. New extension research is presented concerning the use of livestock manure as a fertilizer, new manure application equipment, and practical interpretation of recent nutrient management legislation. Annual attendance is approximately 175 participants with training conducted by state and field specialists and county ANR educators. Evaluations for this program are collected at the end of the program.

**Field to Faucet**

In September of 2014, the Dean of the College of Food, Agriculture, and Environmental Sciences (CFAES) at The Ohio State University announced a water quality initiative called Field to Faucet. This initiative provides funding for research projects, training, and education efforts designed to ensure safe drinking water while also maintaining an economically productive agricultural sector in Ohio. Field to Faucet is a consortium of universities, state and federal agencies, and private companies from across Ohio. Initial funding for this initiative is $5.7 million, provided by CFAES and other partners. To date, there have been 23 research projects covering both applied and more basic water quality research. Some preliminary data generated from these projects has been incorporated in the extension programs discussed earlier. In the future, we look forward to the funding of additional applied research and extension projects through this initiative.

## Summary and Conclusions

Degradations in Lake Erie water quality have been occurring for decades. This decline in water quality is due to a number of factors, but nutrient and sediment loading in surface waters driven by agricultural land use is believed to be the main contributor (Christianson & Tyndall 2011). Compliance with existing and new water quality regulations will be one of the major policy and on-the-ground practice challenges faced by agricultural producers in this region for years to come (Welch and Braunworth 2010). More broadly speaking, farmers are also expected to be stewards of our collective natural resource base in the U.S. The dominant land use in Ohio is agriculture, with over 76,000 farms occupying some 14 million acres statewide. Therefore the capacity to prevent and/or mitigate water quality impacts while also addressing other environmental issues of concern is largely dependent on environmentally focused management by the thousands of farmers across the state (Swinton et al. 2007). Assisting farmers in complying with water quality regulations or enacting voluntary measures on farms in order to proactively address water quality impacts will continue to be an important and growing role for Extension (Tyndall and Roesch 2014).

Extension programs have long focused on water issues (Londo 2004). These traditional extension educational programs are no longer sufficient to address the complex legislative and ecological issues surrounding water quality in Lake Erie. OSUE has developed a more comprehensive and unified approach to better addresses these complex issues.

This approach includes the development of a new OSUE signature program which serves as the umbrella program for a number of OSUE water quality programs. These programs are taught by OSUE state and field specialists, county ANR educators, partners from state and federal agencies, and other interested parties in the state. The signature program approach is designed to provide consistency in message and content across all related programs.

On-farm research looking into nutrient best management practices, including fertilizer application rates and water control structures, is being conducted across Ohio. These research results are being incorporated into the educational programs, extension fact sheets, and other outlets. We provide continuing education credits to CCAs in all areas of nutrient management and quality, utilizing the on-farm research results as they become available. This ensures the information CCA students are receiving is non-biased and accurate, and expands the reach of OSUE training by allowing CCAs to apply their newly gained knowledge on the millions of acres they help manage across Ohio.

Lastly, the Field to Faucet initiative is bringing together university, government, and private partners to conduct coordinated research geared towards resolving water quality issues in Lake Erie. Future funding from this initiative will go to supporting existing and developing new and innovative extension nutrient and water quality programs.

The water quality issues plaguing Lake Erie did not occur overnight, and will not be solved overnight. Given that agriculture is the leading land use in the region, it is appropriate that agricultural producers are being targeted for nutrient management education. However, there are millions of non-agricultural acres that are also contributing to the overall nutrient loading in the lake. If we are to truly address the problems in Lake Erie, all stakeholders need to be involved. The OSUE approach to extension water quality education has focused on the agriculture sector, but future additional programming intends to be as comprehensive and inclusive as possible in regards to partners and clientele. The ultimate impact of these programs will be shown through measured improvements in the quality of water entering into, and residing in, Lake Erie.

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# Lawn to Lake: Lessons Learned from a Collaborative Natural Lawn Care Program

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*University of Illinois Extension Illinois-Indiana Sea Grant Program*

**Abstract:** Illinois-Indiana Sea Grant (IISG) led a multi-state, collaborative natural lawn care outreach program promoting sustainable lawn care practices at the community and household level. The programmatic goal was to improve Lake Michigan basin ecosystem health by reducing pesticide, synthetic fertilizer, and irrigation water use and runoff within the watershed through changing the practices of those responsible for the creation and upkeep of lawns. Targeted audiences were educated about the relationship between Great Lakes Basin watershed health and lawn care practices as well as trained in natural, low-input lawn care methods. The program aimed at achieving efficiency by leveraging collaborating partner resources to adapt existing materials and transfer programs across partners and states. Anticipated program impacts were estimated prior to implementation based on previous program evaluations and available research, and additional evaluations were conducted during the project period (2010–2014). Over the outreach period, over 300 landscape professionals, 400 Master Gardeners and teachers, and 2,000 homeowners were trained in natural lawn care practices. Using an evaluation transfer approach, this effort translates into an estimated reduction of 3.4 million pounds of weed and feed applied to lawns per year with associated decreases in pesticides, phosphorous, and irrigation. This paper reflects on lessons learned though the natural lawn care program evaluation experience and makes recommendations for future programming.

**Keywords:** *community outreach, extension, stormwater pollution, Great Lakes restoration, water conservation, evaluation*

Continued urbanization in the Great Lakes Basin has resulted in rising land acreage devoted to lawns, signaling the potential for increased lawn chemical loadings to the Great Lakes and associated tributaries (SOLEC 2008). Taken individually lawns may seem insignificant, yet, when considered in aggregate, they comprise an estimated one-fourth of land cover in the greater metropolitan Chicago region, rendering lawn runoff a potentially significant source of nonpoint source pollution in urban and suburban watersheds (Akbari and Rose 2001; IAGLR 2002). Lawn care itself is a fragmented activity, involving many thousands of parcels of land held in private ownership. Conventional lawn care methods are resource intensive, with approximately 89 million pounds of non-agricultural combined pesticide-fertilizer products (weed and feed) applied annually and outdoor irrigation comprising 30 percent of community water demand in summer (Grube et al. 2011; U.S. EPA 2013).

The Great Lakes are the source of drinking water for 42 million people in the U.S. and Canada. In the last 100 years, tons of toxins have been added to the limited world supply of freshwater, including from urban and suburban lawn runoff. Illinois-Indiana Sea Grant (IISG) brought together a variety of organizations to develop a unified natural lawn care outreach program funded under the U.S. EPA Great Lakes Restoration Initiative (GLRI 2010). The Great Lakes Restoration Initiative (GLRI) was launched in 2010 to address Great Lakes degradation by providing support for restoration projects. The natural lawn care outreach program aligned with the GLRI *Program I.A.9. Pollution Prevention and Toxics*

*Reduction in the Great Lakes* request for programs promoting and implementing sustainable practices at the household and community level to reduce inputs of pesticides and other potentially toxic substances into the Great Lakes Basin, including low maintenance and natural lawn care and other methods. Prevention of pesticide pollution was also in keeping with the priorities current at the time of the *Lake Michigan Lakewide Management Plan (LaMP) 2008* and the *2006-2011 EPA Strategic Plan* (U.S. EPA 2006; Lake Michigan Technical Committee 2008). Outdoor water conservation was an ancillary benefit of the program, supporting the comprehensive planning goals of the Illinois-Indiana region (CMAP 2010; NIRPC 2011).

The natural lawn care program partners included Illinois-Indiana Sea Grant (IISG), Chicago Metropolitan Agency for Planning (CMAP), Lake Champlain Sea Grant (LCSG), Midwest Pesticide Action Center (MPAC), Northwestern Indiana Planning Commission (NIRPC), Purdue University, and University of Illinois-Extension (UIE). The program name, *Lawn to Lake*, was adopted from a collaboration of partners in Vermont and New York who came together to address the impacts of lawn care on Lake Champlain Basin water quality (Lawn to Lake 2015). A work plan and associated plan for programmatic evaluation was developed by each collaborating organization, leveraging previously successful strategies and existing resources of partners. The program evaluation component was important to the funding and partnering organizations for many reasons, ranging from demonstrating impact and tracking program progress, to facilitating reporting. This paper provides background on natural lawn care, describes the program and evaluation plan as implemented from 2010-2014, and reflects on lessons learned, which will benefit those engaged in similar outreach programming and evaluation efforts.

## Background on Natural Lawn Care

Although lawn care behavior varies greatly between states, neighborhoods, and residents, nationwide studies of consumer lawn care behavior have found that 77% of households apply herbicide, 64% of households fertilize their lawn and 79% of households irrigate their lawn (Khachatryan et al. 2014; Polsky et al. 2014; Sewell et al. 2010). Excess lawn watering leads to greater amounts of runoff that can carry lawn care pesticides and nutrients into nearby bodies of water (U.S. EPA 2003). Combined pesticide-fertilizer product (weed and feed) ingredients vary by manufacturer, but typically contain a formulation of nutrients (nitrogen, phosphate, potassium) and some combination of broadcast herbicides, such as 2,4-D (2,4-dichlorophenoxyacetic acid); mecoprop or MCPP (2-(2-methyl-4-chlorophenoxy) propionic acid); or dicamba (3,6-dichloro-o-anisic acid) (Colorado State University Extension 2014; University of Illinois Extension 2015).

While many watershed management practitioners have noted the difficulty in quantifying the contribution of lawn runoff to receiving waterbodies, nutrients contained in lawn fertilizers can contribute to water quality deterioration (Law et al. 2004; IEPA 2015). When it rains, pesticides and fertilizers run off lawns into storm drains, and then into water bodies (U.S. EPA 2003). High nutrient concentrations in water may cause excessive algae growth that blocks sunlight, and, when algae die, they decompose in a process that removes oxygen from the water. Fish and other aquatic organisms cannot exist in water with low dissolved oxygen levels, leading ultimately to a depleted or dead water body via a process called eutrophication (Correll 1998). The U.S. EPA estimates that 40-60% of nitrogen applied to lawns as fertilizer runs off-site, carried by surface and groundwater (U.S. EPA 2010b).

During intense rain storms, up to 90% of the pesticide applied to a lawn is lost to stormwater via overland flow, and up to 2% of applied pesticides have been found to leach into groundwater (Schueler and Swann 2000). The United States Geological Survey (USGS 1999) found one or more pesticides in every tested surface water body and one-third of all major groundwater aquifers – both sources often used for drinking water (Scott et al. 2006). While the epidemiological research regarding the human health impacts of lawn care pesticides is inconclusive, there is an emerging consensus within the research and regulatory community that health concerns are sufficient to warrant a precautionary approach to

pesticide use (Toronto Public Health 2002). This recommendation, taken in tandem with research linking lawn care pesticides to toxic impacts on aquatic ecosystems, birds and beneficial insects, and soil microorganisms, has led to increased interest in reducing or eliminating lawn pesticide use (Bounds 2007). In Canada, local pesticide bans increased in popularity after a 2001 Supreme Court decision upholding the authority of municipalities to regulate pesticides, which fed into a larger nation-wide momentum and resulted in a national ban on cosmetic uses of weed and feed (Angelo 2013; Cole et al. 2011).

While conventional lawn care is defined by a product-oriented approach centered on the application of synthetic fertilizer and pesticide products, natural lawn care reduces or eliminates the use of these products by focusing on a set of cultural practices aimed toward improving soil health. Soil supports a living ecosystem of organic matter, with healthier soil better able to support plant life and retain water (USDA 2015). Foundational natural lawn care practices include proper selection of grass type, higher mowing, proper fertilization and irrigation, core aeration, topdressing, overseeding, and organic weed and insect management (Osborne 2009).

Proponents of natural lawn care point to the improved environmental outcomes resulting from making the switch from conventional to natural lawn care (Tukey 2007). Natural lawn care not only reduces the need for pesticide and synthetic fertilizer application, but also reduces the amount of irrigation necessary for lawn maintenance. Of the 26 billion gallons of water consumed daily in the United States, approximately 7.8 billion gallons (30%) is devoted to outdoor uses and, of that, as much as 50% is estimated to be wasted due to inefficient watering practices (U.S. EPA 2004). Land cover estimates find that if lawns are considered in relation to agricultural crops, lawns would comprise the largest irrigated "crop" in the United States (Milesi et al. 2005). The Harvard Yard Soils Restoration Project found irrigation requirements on lawns that used natural lawn care were reduced by 30-50% over conventionally maintained ones (Harvard Facilities Operations Maintenance 2009). Mowing higher allows for improved root systems, sufficient photosynthetic tissue system development, and increased evaporative cooling (Bonos and Murphy 1999). Compost topdressing and organic soil amendments incorporate organic matter into soil, increasing the soil water-holding capacity and infiltration, which improves turfgrass drought resiliency. Additions of organic matter to the soil decrease soil compaction (bulk density), which increases soil porosity and hydraulic conductivity, enabling greater water storage from rain events, raising the infiltration rate and decreasing water runoff (Johnson et al. 2006; Johnson et al. 2009; Wischmeier and Mannering 1969). Reducing or eliminating synthetic fertilizer application reduces water use as indicated by evapotranspiration (ET), the total amount of water either evaporated or actively transpired from a plant (Krogman 1966; Feldhake et al. 1983; Barton et al. 2009; McGroary et al. 2011).

## Program Description and Evaluation Design

The program area was the heavily urbanized greater Chicago metropolitan region containing a population of over 9 million people. Program partners created a logic model using the National Oceanic and Atmospheric Administration (NOAA) Assessment, Design, Development, Implementation and Evaluation (ADDIE) framework (NOAA 2009). Efficiency in program design was achieved by transfer of existing materials (needs assessments, program evaluations, factsheets, brochures, manuals, logos, websites, project themes, research data) from existing partner programs, including: *Natural Lawn Care Training for Professional Landscapers and Municipalities* (Midwest Pesticide Action Center, previously Safer Pest Control Project); *Lawn to Lake/Don't "P" on Your Lawn* (Lake Champlain Sea Grant); Extension's *Lawn Talk* website (University of Illinois Extension) and *Protect our Water and Environmental Resources* (Illinois Indiana Sea Grant/Purdue University). Selected logic model components including the inputs and activities occurring over the project period, program participants, and objectives are shown in Table 1. Measurable program participation metrics were assigned to the program objectives for five activity areas, including: branding and messaging,

**Table 1.** Selected Natural Lawn Care Program Logic Model Components.

| Inputs (What we invest) | Participants (Who we reach) | Activities (What we will do) | Objectives |
|---|---|---|---|
| 1. Staff expertise/time of program partners (Illinois-Indiana Sea Grant, Lake Champlain Sea Grant, Midwest Pesticide Action Center (previously Safer Pest Control Project), Purdue University, University of Illinois Extension.).<br>2. Volunteer program partners resources.<br>3. Facilities for trainings.<br>4. Technology equipment (laptops, projectors, internet/web technology, video).<br>5. Materials which include handout materials, pamphlets, evaluation forms, etc.<br>6. Results of previous research.<br>7. Funding. | 1. Residents.<br>2. Landscape professionals.<br>3. Master Gardeners/ Naturalists (UI Extension).<br>4. Municipal government.<br>5. Retailers.<br>6. Conservation and resource management groups.<br>7. Community partners. | 1. *Branding and Messaging.* Design a program logo and create consistent outreach messaging.<br>2. *Develop Outreach Materials.* Update existing web-sites and materials using program logo and leveraging existing material from partners.<br>3. *Training for Targeted Audiences.* Conduct training workshops for targeted audiences, including: (a) landscape professionals and municipalities, (b) Extension's Master Gardener and Master Naturalists, (c) schools, and (d) homeowners.<br>4. *Retailer Outreach.* Conduct a direct outreach program to lawn product retailers to promote natural lawn care product availability.<br>5. *Pilot Grounds Care Program.* Develop and implement a pilot grounds care program. | 1. Program logo and themes for use in outreach.<br>2. Website hits will increase by ten percent.<br>3. (a) Total of five workshops directly reaching 330 landscape professionals.(b) Total of six Master Gardener training workshops reaching a total of 180 volunteers. (c) Three workshops for school grounds keepers reaching 60 school staff. Total of eight teacher trainings (d) Three educational series for homeowners trainings, reaching a total of 200 homeowners.<br>4. 40 retail program participants.<br>5. Implement a pilot program in 3 communities. |

outreach material development, training workshops for targeted audiences, retail outreach, and pilot community grounds care program.

The primary focus of the evaluation effort was tracking participation in project activities to ensure proper management of project resources, keeping the project on track, and assessing percent completion rates for project reporting. For example, attendance of the in-person training workshops for landscape professionals, school grounds-keepers and municipalities; train-the-trainers; and homeowners was tracked, as well as the number of participating retailers and communities over the project performance period. A secondary evaluation objective was measurement of program effectiveness in achieving the stated outcomes. The outcome components of the natural lawn care program logic model are shown in Table 2. The outreach team worked to create a program aligning short-term learning outcomes with medium-term behavior changes, with the aim of achieving the long-term impact of reduced pesticide and nutrient

**Table 2.** Natural Lawn Care Program Logic Model Outcomes.

| **Learning** (*Short-term*) | **Behavior** (*Medium-term*) | **Impacts** (*Long-term*) |
|---|---|---|
| 1. Program participants will have increased understanding of the connection between lawn and landscape care practices and water quality.<br>2. Program participants will have increased knowledge of:<br>• *watersheds and urban water cycle*<br>• *soil health*<br>• *composting*<br>• *fertilizer ingredients (weed and feed pesticide and nutrient content)*<br>• *natural lawn care best management practices*<br>• *rain-friendly gardening practices* | 1. Residents will be able to practice sustainable lawn and landscape care practices.<br>2. Trained professional landscapers will use natural lawn care principles at client sites.<br>3. Master Gardeners pledge to implement a sustainable lawn/landscapes project within one year.<br>4. Master Gardeners reach residents though volunteer work.<br>5. Teachers and informal educators will use the EnviroScape® model in the classroom and at educational events.<br>6. Retailers will carry consumer education materials. | 1. Reduced application of pesticides/herbicides to lawns (reduced contaminant concentrations in runoff).<br>2. Reduced application of phosphorous/nitrogen containing fertilizers to lawns (reduced phosphorous/nitrogen concentrations in runoff).<br>3. Reduction in lawn irrigation. |

lawn runoff into the Great Lakes Basin.

Short-term knowledge outcomes were measured by administering a pre-workshop survey to establish baseline participant knowledge, attitude, and skills. An immediate post-workshop survey assessed gains in these areas over the duration of the workshop. In the case of professionals and schools workshops, self-reported behavior change after an extended period (between 6 to 12 months) was measured. It is important to note that the planned evaluation effort did not include observational monitoring of program participants (i.e., field observations of actual weed and feed applications) or actual pesticide and nutrient monitoring in the program watershed(s). At the outset of the program and evaluation design, it was recognized that it would be prohibitively expensive to measure actual quantities of combined weed and feed applications and the associated watershed loading reductions in pesticides and nutrients before and after the project. Pollution prevented was therefore extrapolated from participation counts, supplementary evaluations, and existing research.

## Natural Lawn Care Program Results

The *Lawn to Lake* logo was adopted from the Lake Champlain Basin Program (lawntolake.org) and used to brand outreach materials. In addition, the program team identified the major thematic topic areas and messaging to be presented in program outreach materials for consistent outreach messaging (Table 3). Project partners identified five topic areas: watersheds, compost, lawns and alternatives, right plant/right place, and rain-friendly landscaping. The primary program message and the associated desired behavior change were identified for each topic area. Outreach and training workshop materials were adapted and branded. Materials included tabling display and handouts (bookmarks, cards, pencils, brochures); websites (*Lawn Talk* English and Spanish versions, Lawntogreatlakes.org); professional and municipal workshop binders; save the dates and press releases; train-the-trainer power points and brochures; fact sheets and brochures for homeowner outreach; retail outreach materials including rack cards and

**Table 3.** Natural Lawn Care Program Topic Areas and Messaging.

| Topic | Program Messaging | Associated Behavior |
|---|---|---|
| **Watersheds** | • What you put on your lawn ends up in the lake/local waters/ groundwater aquifers<br>• We all live in a watershed/we all live downstream | • Use fewer lawn chemicals (pesticides)<br>• Reduce water runoff by retaining water on site. (rain gardens, rain barrels) |
| **Compost** | • Living soil – soil comes first<br>• Save money by leaving clippings on the lawn | • Use compost, compost tea, natural fertilizers<br>• Soil test |
| **Lawns and alternatives** | • Recognize the function of your yard/landscape<br>• Landscapes provide ecosystem services<br>• Healthy landscapes are healthier for people and the environment. | • Natural Lawn Care Practices<br>• Landscape design and planning<br>• Incorporate lawn alternatives |
| **Right plant, right place** | • Different plants have different needs | • Choose appropriate grass type and plants for your site |
| **Rain-friendly landscaping** | • Rainwater is a resource | • Reduce water runoff by retaining water on site. (rain gardens, rain barrels) |

posters; and pilot community manuals. The latest version of the UI Extension website went live July 2012, revised to include information on natural and organic lawn care. The *Lawn Talk* website received a total of 49,679 hits over the project period, an 8% increase from the comparable pre-grant period.

Over 300 participants from professional lawn care companies, municipalities, school maintenance staffs, and others attended natural lawn care workshops during the project period (March 2011 to April 2014). A combined analysis of administered pre-and immediate post-surveys found that an average of 92% of respondents found the workshops to be very or mostly relevant to their needs and interests; 96% found the information presented to be useful in their lawn care and landscaping jobs. Respondents rated the workshops as good (48%) to excellent (46%), and the majority (81%) said they were better prepared to implement low input lawn care practices on client sites as a result of workshop attendance. The broader sustained impact of the workshops on participants was assessed by analysis of post-workshop resurveys conducted 8 months after the workshops. The results of these assessments need to be interpreted with caution, not only due to very low response rates across the resurveys, but also because the surveys collect self-reported behavior. Participants reported a 22% increased use of organic fertilizer on managed grounds

(from 57.7% to 80%); 26% were more likely to base fertilizer use choices on the results of a soil test (from 34.1% to 60%); 36% were more likely to follow the instructions on the container for fertilizer application and 40% more likely to follow label instructions for pesticide application (from 34.1% to 70% and from 39.5% to 80% respectively).

Over 400 Master Gardeners, teachers, and informal educators were reached, representing over 10% of the Master Gardeners in Illinois. Upon completion of the workshops, Master Gardeners, informal educators, and teachers were able to borrow EnviroScape® models for use in the classroom and at educational events. In the first year of the program, six models were placed across the project region for informal educator use. As a result, more than 1,000 people annually learned about the connection between healthy lawns and healthy lakes. UIE budget cuts and resulting staffing changes limited the evaluation capacity of the train-the-trainer component to participation counts and the baseline data collected though the Master Gardener volunteer reporting system.

The retail component of the program reached 36 retailers who agreed to have store information placed on the website retailer map promoting natural lawn care products and to carry P-free fertilizer options. In the first year of the outreach program, the Illinois Phosphorous Law (Illinois HB 6099 2010) restricting applications of phosphorous-containing fertilizer was passed. As a result, synthetic fertilizer products containing phosphorous have been greatly reduced in the supply chain in the past half-decade. For this reason, it was not possible to evaluate the impact of the program outreach on retail product availability independently of other supply chain effects.

The pilot community grounds care program was developed via a participatory agency stakeholder process led by the Northwestern Indiana Regional Planning Commission (NIRPC). The result was a comprehensive outreach strategy for communities in the NIRPC planning region that included: information booths at environmentally themed events, e-mail blasts, outdoor banners, newspaper articles, a *Lawn to Lake Guidebook for Illinois and Indiana*, and community presentations.

A transfer of evaluation results was undertaken to approximate the long-term programmatic impact. Estimates were obtained by taking the number of program participants and extrapolating to the estimated amount of reductions in combined fertilizer-pesticide product (weed and feed) applications. In considering the estimates, it is critically important to note two things. First, preliminary estimates use best available information and assumptions to provide a rough estimate of expected impacts. In actuality, lawn care behavior, including the frequency of application, rates of application, and pesticides used, is highly variable by location, season, weather, and other factors. Second, the estimates are based on reported behavior and not actual biological loadings of pesticides and nutrients in the watershed. Due to the scarcity of research examining pesticide and nutrient losses from urban soils into the watershed, estimates of reduced pesticide and nutrient loadings to waters were not attempted for the impact assessment (Carey et al. 2012).

As location-specific information on lawn acreage and product use was not available, data from previous research were used to estimate the impact of a typical combined fertilizer-pesticide product when applied to an average size lawn at recommended application rates. Average lawn sizes were based on a best-available comprehensive 1995 study estimating a national average lawn size of 0.20/acre (Vinlove and Torla 1995). The estimates assumed an average combined fertilizer-pesticide product application frequency of twice per year, an average product pesticide content of 0.8%, a minimum 140 lbs/acre single application rate for weed and feed, which translates into 1.12 lbs of pesticide/acre/application. The actual pesticide content of a typical combined fertilizer-pesticide product includes 2,4-dichlorophenoxyacetic acid (0.61%), (+)-(R)-2-(2 methyl-4-chlorophenoxy) propionic acid (0.15%), Dicamba: 3,6-dichloro-o-anisic acid (0.05%) (Homziak, J. personal communication March 9, 2009; and Kostelnick, M. personal communication March 9, 2010).

The associated water savings were also estimated using a quantitative relationship between nitrogen application and turfgrass evapotranspiration to represent the effect of

**Table 4.** Estimated Impacts of the Lawn to Lake Program.

| | Landscape professionals, municipalities, and schools | Master Gardeners and teachers | Homeowners |
|---|---|---|---|
| **Outreach** | 7 workshops<br>304 attendees | 20 workshops<br>432 attendees | 30 workshops<br>2,005 attendees |
| **Residents reached** | 80,560 | 40,780 | 2,005 |
| **Lawn care acres impacted** *(based on Vinlove, F.K. & Torla, R.F. (1995); Master Gardener program data)* | 16,110 | 8,150 | 320 |
| **Estimated weed and feed reduction (lbs/year)** *(sources Homziak, J.; and Kostelnick, M. via March 9, 2009 conversations; SPCP data)* | 2.2 million | 1.1 million | 43,308 |
| **Pesticides (lbs/year)** | 16,310 | 8,260 | 325 |
| **Phosphorous (lbs/year)** | 108,760 | 55,050 | 2,165 |
| **Estimated water savings (gallons/year)** | 662 million | 335 million | 13 million |

fertilizer level on lawn water use (Krogman 1966; Feldhake et al. 1983; and Ebdon 1999). The recommended amount of nitrogen for the Midwest region is about 1 pound per 1,000 square feet each year (Bigelow et al. 2013). A homeowner using a typical combined fertilizer-pesticide (weed and feed) product applies nearly twice that amount: about 1.9 pounds N per 1,000 square feet every year, based on 28% N content of typical weed and feed product and two applications per year (Homziak, J. personal communication May 29, 2012). Reducing the residential fertilizer application to the recommended amount could save nearly 9,000 gallons of water a year for an average sized lawn.

The resulting estimated impacts for the natural lawn care outreach project were updated using participant counts and available outcome metrics from the program evaluation. Outreach to primary user groups resulted in an estimated reduction of 3.4 million pounds of weed and feed applied to lawns per year with associated decreases in pesticides, phosphorous, and irrigation (Table 4). The estimated program impacts from evaluation and research transfer must be interpreted with caution. Lawn care behavior is widely acknowledged to be complex and spatially varied (Cole et al. 2011; Martin et al. 2015). Actual lawn chemical amounts contained in runoff is highly variable and dependent on many factors such as soil type, lawn maturity, grass type and health, and the frequency and intensity of rainfall. There is significant opportunity to improve on outcome evaluation by undertaking more research, data collection, and modeling, as well as estimating the resulting economic and environmental values of prevented pollution.

## Conclusion, Lessons Learned, and Recommendations

Overall, program design was effective in meeting the stated program participation objectives. The program trained over 300 landscape professionals,

400 Master Gardeners and teachers, and 2,000 homeowners in natural lawn care practices, in addition to working with 36 retail outlets. The program partners believe that the success in meeting targeted objectives is in large part due to the systems perspective used in its development, which cultivated not only the demand for natural lawn care products and practices among homeowners, but also the capacity of lawn care service and lawn product retailers to meet this demand. The program logic model also served to unify multiple partnering agency strategic objectives towards meeting the goals of the natural lawn care program, and provide a useful building block for similar outreach efforts.

The key to building on project successes is to address the barriers to adoption of natural lawn care practices identified by the program participants in the evaluation surveys. Barriers reported are: lack of information and training; high costs of starting a natural lawn care program; and the perception that natural lawn care practices do not deliver acceptable results. The lack of information and training can be addressed by incorporating natural lawn care into ongoing Extension efforts, such as: updating and maintaining the information resources available online (both English and Spanish language) to commercial lawn care firms and retailers; developing an Extension-led planning program in collaboration with trained staff from municipalities and schools that will assist others in the region to transition to recommended practices; and incorporating natural lawn care training into Pesticide Applicators Certification training programs.

One third of workshop participants perceived high costs as a barrier to the implementation of a natural lawn care program and half noted the perceived non-reliability of natural lawn care practices as a concern. These findings may be due to the fact that cost savings generally are only realized in the long run, after a transition period that can involve higher initial cost outlays (performing core aeration, over seeding) combined with reduced lawn aesthetic during the period of transitioning a lawn from conventional to natural. The latter issue illustrates the extent of resistance to adoption of natural lawn care practices and underscores the need for publicly-visible natural lawn care demonstration sites combined with messaging campaigns educating the community about what to expect for lawn aesthetics.

To address cost issues, Extension-led cooperative research is needed to develop options that can improve the financial feasibility of practices, including analyzing and identifying the actual costs and returns of different practices, comparing costs and returns of conventional versus natural lawn care practices, and researching how recommended practices may be modified to reduce costs and/or enhance revenue. Another possibility is to explore incentive programs to offset costs incurred during the transition period. Social marketing and related social science research is also desirable to better design and craft effective messages for commercial firms to use with their clients. This is especially important where there is an increased cost associated with implementing recommended practices, a cost that has to be passed on to the customer or reflected in a higher demand on the municipal or school budget.

The most prevalent concern revealed in the evaluation responses (the perceived non-reliability of natural lawn care practices to deliver a high quality, visually appealing lawn) can also be addressed by future Extension-industry research. Working with collaborators in municipalities, schools, and commercial firms, Extension turf researchers can design programs to compare lawn health and appearance outcomes of conventional and natural practices. Ideally, this can be combined with research on the costs and profitability of various practices, as well as a deeper exploration of the environmental impact of specific cultivation practices. Taken together, continued natural lawn care program research and evaluation can advance outreach to improve Great Lakes Basin watershed health.

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# Integrating Extension, Teaching, and Research for Stormwater Management Education

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**Abstract:** Stormwater management is a concern for communities in the United States, particularly those with populations over 10,000 because of mandates to reduce runoff volumes and associated pollutants. An extension Stormwater and Greenspace Work Group was organized at the University of Nebraska–Lincoln (UNL) in 2006 to develop educational programs addressing municipal stormwater runoff using green infrastructure and other best management practices. A USDA-NIFA integrated grant was received in 2009 which greatly expanded the audience and scope of programming to include extension, education, and research components. Extension programming was targeted at design and green industry professionals, MS4 stormwater program managers, municipal officials, Master Gardeners, and homeowners. Extension activities included: meeting presentations; all-day rain garden workshops/installations; green infrastructure tours; rain barrel construction workshops; web-based resources; interactive rain garden models; youth activities; and publications. Academic programs in landscape architecture and landscape horticulture expanded curriculum in green infrastructure, low impact development, and stormwater best management practice design and construction. Efforts have culminated in new course lectures as well as studio design projects that conceptually addressed real-world clients and stormwater management projects. Project research studies evaluated in-situ rain garden hydrologic and plant growth attributes, homeowner perspectives on rain garden installation programs, and current regional bioretention design standards. The strong integration of extension, teaching, and research, which can often be a significant challenge, is a primary key to the success of UNL stormwater management programming. The resulting synergy has helped communities and individuals more effectively manage stormwater quantity and quality while building a knowledge-base that will support future initiatives and programs.

**Keywords:** *phase II community, MS4, green infrastructure, low impact development, rain gardens, water quality, service learning, youth education*

Traditional management approaches treat stormwater in developed landscapes as a nuisance to be conveyed away as quickly as possible with curbs, gutters, and storm drains, often referred to as "gray infrastructure." The new paradigm, in common practice today, views stormwater as a resource to be retained and used on-site or allowed to infiltrate. Management practices and green infrastructure such as rain barrels, rain gardens, bioretention cells, green roofs, and pervious pavement manage stormwater close to where it falls. These practices and structures conserve water, increase groundwater recharge, and improve surface water quality by retaining and filtering runoff that can contain a wide range of contaminants.

The Environmental Protection Agency (EPA) promulgated rules establishing Phase I of the National Pollutant Discharge Elimination System (NPDES) stormwater program in 1990 as part of the Clean Water Act. This program generally required that municipalities with populations of 100,000 or greater implement a stormwater management program as a means to control

polluted discharges. The Stormwater Phase II Rule, issued in 1999, extended requirements to municipalities with populations between 10,000 and 100,000 as well as certain other urbanized areas. In Nebraska, there are two Phase I and ten Phase II municipalities as well as several other Phase II entities. Public education and outreach are major components of Phase II implementation.

This federally-mandated stormwater management ruling generated a significant need for public education in communities of all sizes across the United States. In Nebraska, the Phase I cities of Omaha and Lincoln have implemented a variety of programs primarily using city personnel and consulting firms, although University of Nebraska–Lincoln (UNL) Extension has frequently been a partner in these outreach efforts when green infrastructure was proposed as a lower-cost alternative to traditional gray infrastructure practices. The smaller Phase II municipalities generally have more limited staff and budget resources to meet stormwater management mandates. Consequently, these communities have actively sought extension leadership for stormwater management programming.

Requests from Nebraska municipalities, green industry professionals, and others for stormwater management training and educational materials led to the organization of a UNL Stormwater and Greenspace Work Group in 2006 to develop educational resources and programs. A USDA National Institute of Food and Agriculture (NIFA) National Integrated Water Quality Program (NIWQP) grant titled "Improving and Conserving Water Resources through Stormwater Management Education for Community Decision Makers of Today and Tomorrow" was received in August 2009 that greatly expanded the scope of stormwater management programming and audiences reached. Funding was initially granted for a three-year project, and two one-year extensions were received, with the project ending in August 2014. This manuscript focuses on the design, implementation, and evaluation of this grant-funded project, with the objective of providing the reader with concepts that can be applied to other projects addressing municipal stormwater management education.

## Objectives

A USDA-NIFA project needs to consist of all three functions of agriculture knowledge (i.e., research, education, outreach/extension) to be classified as integrated (USDA-NIFA 2015). Projects frequently have research as the primary focus with extension and education secondary. In contrast, this project was designed from the outset with extension, education, and research comprising approximately 50%, 30%, and 20% of the effort, respectively. The overall goal was to improve water quality while conserving water resources through stormwater management and green infrastructure using a highly integrated approach of extension programming, classroom education, and field research (Figure 1). Specific objectives for the three components to achieve this goal were:

### Extension

1. Provide science-based educational materials and hands-on learning experiences for municipal leaders and residents of Nebraska Phase II municipalities to:
   a. Increase the use of water-sensitive landscape design and best management practices.
   b. Assist in making viable, cost-effective decisions for municipal stormwater management.
   c. Help meet the public education and outreach measures as established by EPA.
2. Design and implement a multi-faceted experiential learning program that actively engages youth to increase their understanding and knowledge of stormwater hydrology and green infrastructure, and improve the skills needed for successful career preparation and as future decision makers.
3. Develop and deliver educational programs and hands-on learning opportunities for green industry and design professionals to help meet the growing demand for sustainable greenspace solutions.

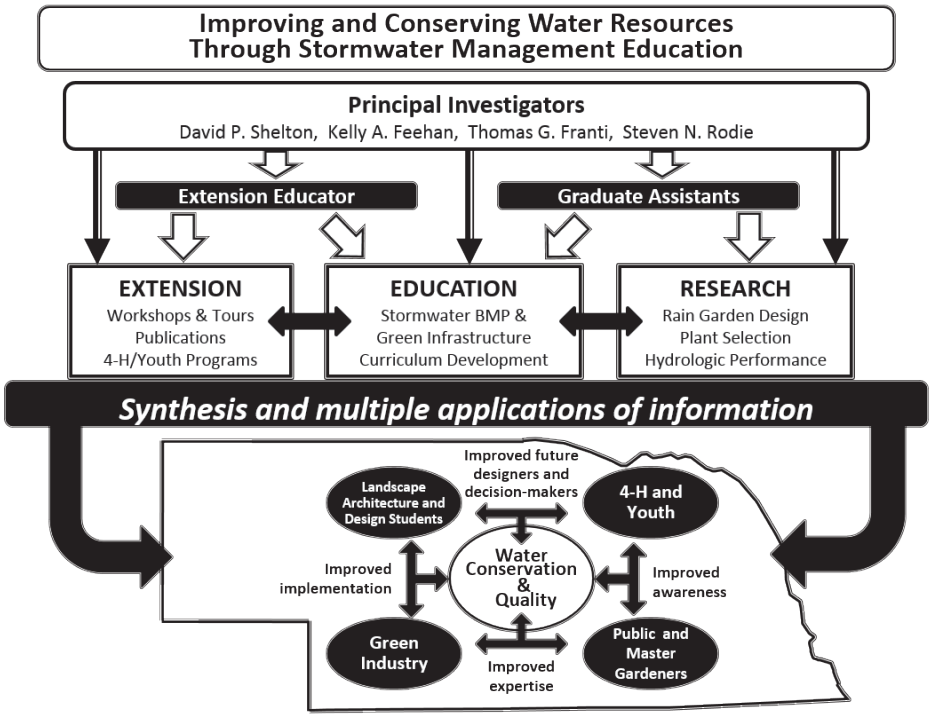


**Figure 1.** Schematic showing project integration, primary audiences, and selected outcomes.

4. Integrate stormwater hydrology and greenspace topics into Master Gardener training to prepare them for incorporating new water perspectives into their outreach programs.
5. Share information developed in this project to increase the knowledge base of green infrastructure methods for stormwater management.

**Education**

1. Integrate stormwater management and green infrastructure topics into new and existing Landscape Architecture, Landscape Design, and Turf/Landscape Management courses.
2. Develop a new professional elective course in the Landscape Architecture undergraduate curriculum that focuses on elements of stormwater management and green infrastructure.
3. Develop and coordinate interdisciplinary stormwater management and/or green infrastructure service learning projects for landscape architecture, civil engineering, water science, and planning students.
4. Educate and provide teaching and research opportunities for two Master's Degree students with a specific emphasis on green infrastructure components of stormwater management.

**Research**

1. Evaluate plant growth and performance in established rain gardens under Nebraska climate and conditions to enable revised plant selection and care recommendations.
2. Evaluate the hydrology of established rain gardens under Nebraska climate and conditions to enable revisions of design, installation, and maintenance recommendations.

## Methodology

Numerous approaches were used to meet project objectives. Extension efforts ranged from conventional techniques such as news releases, meetings, and publications to focused, innovative

techniques that included day-long hands-on rain garden installation workshops, a 1:24 scale table-top working rain garden model, an interactive rain garden animation, and a multi-component youth education kit. New courses and lectures focusing on green infrastructure were developed for classroom education, and service learning projects involving real-world clients and real-world issues were used. Research efforts used a unique stormwater runoff simulator to evaluate hydrologic properties of existing residential rain gardens. Selected efforts are described below.

**Extension**

***Rain Garden Installation Workshops***. Ten workshops, with a total of approximately 200 participants, were held across Nebraska, primarily in Phase II municipalities. Participants included Extension Master Gardeners, landscape architects, engineers, landscape designers, UNL extension staff, municipal officials, and homeowners. The goals of the workshops were to: 1) provide participants with knowledge about green infrastructure methods for urban stormwater management and information on rain garden design, construction, and maintenance; and 2) develop a demonstration site in the community that could be used for future activities such as youth programming along with hydrologic or plant growth and survival evaluations.

The workshops were typically structured with a classroom-type setting in the morning where participants learned general information about stormwater management as well as information about rain garden sizing, plant selection and placement, construction, maintenance, and other related topics. Initial designs and plant selection were generally done by extension personnel prior to the workshop and presented during the morning session. The afternoon session was held outdoors, weather permitting, with participants partaking in each step of the rain garden installation including: marking of layout; sod removal; soil moving to level the bottom and build berms; creating and leveling inflow and overflow sites; incorporation of soil amendments (if used); planting; and mulching. Depending on specific site conditions, some of the work was done by extension and/or municipal personnel prior to the workshop. On three sites, one each in western, central, and eastern Nebraska, Master Gardeners assisted with maintenance and gathering information on plant performance using a "Green Observer" form that was developed to assist with uniformity of collected information.

A survey at the conclusion of three of the workshops completed by 34 of 45 participating Master Gardeners, landscape designers, landscape architects, engineers, and UNL Extension staff showed the following combined results:

- 100% reported an increased knowledge of how to design, install, and maintain a rain garden.
- 94% reported an increased awareness and understanding of stormwater runoff issues for water quality and stormwater best management practices.
- 90% planned to use at least one best management practice that reduces potential water pollutants.
- 83% planned to use practices other than a rain garden on their properties or properties they manage to reduce stormwater runoff.
- 81% planned to recommend and/or design/install rain gardens as part of their job.
- 77% planned to install a rain garden on their own property.

***Rain Garden Model***. A portable, 40 in. x 42 in., 1:24 scale model rain garden setting (including house, driveway, street, front yard, and surrounding landscape) was designed and built to demonstrate the layout and function of a residential rain garden. Water is poured through a "cloud" above the house and then runs off the roof through gutters and downspouts. Water from approximately one-half of the roof flows into a rain garden on one side of the property, while the remaining water flows onto a representation of a poor lawn or the driveway on the other side of the property and then into a street storm drain, contrasting the capture and slow infiltration of water in the rain garden with the runoff and erosion from impervious surfaces.

The model was designed to accurately reflect proper rain garden specifications such as proximity to the house, depth, berms, water entrance, overflow design, aesthetic and functional planting design, and aesthetic and maintainable integration into the surrounding landscape. The model has been

used to illustrate the concept and proper design of residential rain gardens to hundreds of students, home owners, and interested citizens at over 20 public events, including water festivals, school educational events, university service learning meetings, regional gardening shows, the Nebraska State Fair, Earth Day celebrations, and others.

***Rain Garden Animation***. An on-line, interactive rain garden animation was developed to engage homeowners and others interested in learning the basics of rain garden function and design (http://water.unl.edu/documents/RainGardenAnimation_9-30-09.swf). Using the rain garden model referenced above as a backdrop, viewers are able to click on labels throughout the images and bring up brief descriptions of nearly every aspect of residential rain gardens, including yard location, roof measurements for volume calculations, runoff routing into and out of the garden, depth and sizing of garden, soil testing, and plant selection and usage. The garden can be viewed in above-ground and below-ground perspectives to show both the aesthetics of the landscape features and the functional attributes of water infiltration, root growth, and garden excavation and depth. A simulated rain event can be viewed in either perspective to show the flow of water from the roof to the garden and through the soil.

The animation is used regularly in Master Gardener training sessions on green infrastructure and rain gardens, and has been a valuable "first reference" for people interested in learning about rain gardens. Requests from at least eight land grant universities, botanical gardens, and other educational organizations from around the country have been approved for linking to the animation from other websites.

***Rain Barrel Workshops***. Approximately 15 rain barrel construction workshops were conducted. Three of the workshops were specifically for Master Gardener training and two for youth and families. Two others for the general public were taught by Master Gardeners - an example of train-the-trainer. Similar to the rain garden workshops, these were also hands-on with participants doing most of the actual construction. Information on stormwater management, runoff pollutant reduction, and other best management practices was also presented in addition to rain barrel construction, use, safety, and maintenance topics.

***Green Infrastructure Tours***. Ten Green Infrastructure tours were held, having approximately 500 participants that included municipal employees, engineers, landscape architects, landscape designers, Extension Master Gardeners, Extension staff, and others. The tours were held primarily in the Phase I cities of Omaha and Lincoln due to a greater number and diversity of sites available. Sites covered a gamut of practices including bioretention gardens, bioswales, green roofs, rainwater harvesting, a pervious recycled glass patio, permeable pavement and pavers, constructed wetlands, curb-free site development, a green wall, and others. Tours typically started at 9:00 a.m. and ended at approximately 3:30 p.m. The registration fee was usually $30 which included lunch and transportation by chartered bus. A survey designed to evaluate knowledge gain and potential practice change was distributed at the end of the tours. Surveys were completed by 65 participants of the tours held in 2011, with the following combined results:

- 100% reported an increased understanding of the basic design concepts and principles of best management practices for stormwater management.
- 98% reported an increased knowledge of how to design, install, and maintain green infrastructure practices.
- 98% planned to change a practice they currently use to a practice that would improve stormwater management.
- 94% planned to seek opportunities to design/install green infrastructure practices for improved stormwater management.

These tours are continuing as an annual event in both Lincoln and Omaha, well beyond the scope of the original project - a testament to their value and popularity.

***Youth***. A wide range of activities including hands-on rain barrel building workshops, the rain garden model, "Water Explore Mini Camps," hands-on learning sessions at water festivals, and others

have provided approximately 6,000 youth with an increased awareness and understanding of stormwater issues and green infrastructure. At most events, youth were asked the pre and post-session questions: "What is a watershed?;" "What is stormwater runoff and where does it go?;" "What is nonpoint source pollution?;" and "What is gray versus green infrastructure?." At the beginning of the event, 100% of participating youth indicated they did not know what a watershed is; what nonpoint source pollution is; or what is meant by gray and green infrastructure. Only a few knew that stormwater typically flows directly to water bodies, transporting pollutants. Following the event, over 85% indicated they now understood what a watershed is; described at least two examples of water pollution; and named at least two practices they could implement to help reduce water pollution and/or slow runoff water from the property where they live.

Another approach to youth-oriented stormwater management education was the creation of comic-type characters "Stormwater Sleuth" and "Running Rain" (Figure 2) as mascots for youth educational programming. Stormwater Sleuth teaches from a watershed perspective as she views the landscape from overhead, while Running Rain teaches with his experiences as stormwater runoff flowing over surfaces, into storm drains, soaking into soil, etc.

These characters were used in the development of a 16-page, comic-style booklet (Feehan et al. 2012) where the reader can follow their adventures to learn about stormwater runoff, water pollution from runoff, and practices such as sweeping up grass clippings, using rain barrels, rain gardens, green roofs, and permeable pavement to help slow stormwater and keep runoff clean. The booklet also includes inquiry-based activities, a maze, and crossword puzzle. In 2014, the Sleuth booklet was downloaded 30,545 times from the UNL publications website.

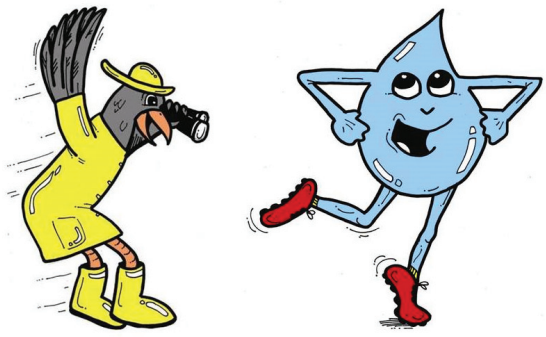

**Figure 2.** Stormwater Sleuth and Running Rain characters.

The booklet was included in an educational kit that also contained a magnet in the shape of a water droplet, a bookmarker to promote awareness, a water droplet-shaped sponge to illustrate that stormwater should be soaked up rather than allowed to run off, a rain gauge to track rainfall amounts, a specially-developed card game (120 cards each with stormwater terminology and a different photograph) to teach about pollution threats and practices to help reduce these threats, six stormwater activity sheets and a companion educator information sheet, and a specially designed drawstring bag to hold kit contents.

Funding was received from the Nebraska Environmental Trust through the Nebraska Academy of Sciences Public Information and Education Grant Program in 2014 to provide one of these kits to each public and private elementary school in each of the ten Nebraska Phase II communities, and conduct an evaluation of kit usage by educators using the kits. Approximately 125 kits and evaluation surveys were distributed in late 2014. Survey completion requests and subsequent reminders were sent in early 2015. As of mid-2015, 29 primarily 4$^{th}$ and 5$^{th}$ grade teachers, representing a total of 1,201 students, had responded to survey requests. Of the respondents, 12 had used kit resources and 28 indicated that they either plan to use kit resources in the future, or would share the kit with another teacher. Of the 12 who had used kit resources, all indicated that their own awareness and understanding of stormwater management and green infrastructure had increased, all planned to continue using kit resources in the future, and 11 said their students planned to make a change in habits such as sweeping grass clippings off pavement, picking up litter, recycling leaves, etc. Four used the pre- and post-tests that were provided, with all indicating that their students showed an increased awareness of both stormwater and green infrastructure as a result of using kit resources.

***Professional Education Credits***. During 2012 and 2013, engineers, landscape architects, and other professionals could have earned up to 46 hours of credits to meet professional license continuing education requirements by participating in Extension programs such as tours, workshops, a post-construction symposium, and other events. These professionals expressed appreciation for being able to receive quality continuing education at a low price without the added expense of long distance travel, which was an additional incentive for their participation.

***Website***. UNL Extension maintains a comprehensive water-focused website http://water.unl.edu. Considerable effort was devoted to developing and maintaining up-to-date stormwater-related items for the Stormwater Management page. Subtopics included: Low Impact Development; Green Roofs; Rain Gardens; Stormwater Regulations; Publications; Online Learning; Stormwater Education for Kids; and others.

***Printed Publications***. UNL Extension has two main categories of printed publications: *NebGuides*, which are limited to four printed pages and generally cover a single, specific topic; and *Extension Circulars* which can have more than four printed pages and provide more comprehensive coverage of a topic or topics. Considerable emphasis was placed on developing printed publications during this project. Twelve stormwater-related *NebGuides* and four *Extension Circulars* were developed. Selected *NebGuide* titles include: "What Stormwater Management Is and Why It Is Important;" "Rainwater Harvesting in Residential-Scale Landscapes;" "Rainwater Harvesting with Rain Barrels;" "Rain Garden Design for Homeowners;" "Disconnecting Downspouts and Impervious Surfaces;" and "Green Roof Basics." Similarly, *Extension Circular* titles are: "Stormwater Management Terminology;" "Stormwater Management on Residential Lots;" "How to Make a Rain Barrel;" and "Rain Garden Design - Site and Selection Guide." The latter circular is designed to be printed, similar to a conventional publication, or used interactively online by users seeking tailored design and other information generated from data specific to his/her own situation. These publications are also accessible online from the water.unl.edu/stormwater and UNL Extension webpages.

**Education**

***Course and Lecture Development.*** Rain garden and green infrastructure curriculum in Landscape Horticulture and Landscape Architecture at UNL, as well as in Landscape Horticulture and Environmental Studies at the University of Nebraska at Omaha (UNO), have expanded significantly with a variety of new course lectures, case study assessments for existing and proposed green infrastructure projects, and student field tours of existing projects. Students from different backgrounds and disciplines were encouraged to take these courses, adding significant value and integration to class and other discussions. Additionally, studio design projects that addressed real-world clients and stormwater management projects have been completed, including the conceptual design of stormwater best management practices for the corporate headquarters of Cabela's in Sidney, NE.

***Service Learning Projects.*** Several rain garden projects have been coordinated through the UNO Service Learning Academy. Each involved a unique blend of students, community projects, and outcomes. The following projects were initiated:

- UNO students worked with ninth grade science honors students from Ralston High School in Ralston, NE to identify native plants and plant communities and then design an outdoor classroom (including rain gardens and runoff management strategies) in Ralston's Oak Park.
- UNO students worked with sixth grade science students from Benson West Elementary school in Omaha to complete ten conceptual rain garden/prairie garden designs for the school site that were then integrated into a final design which was built with Nebraska Environmental Trust/Sustainable Schoolyard Partnership grant funding and in-kind Omaha Public School (OPS) and UNO donations.
- UNO students developed a detailed planting design (including four rain gardens and a bioswale) for an educational landscape

demonstration surrounding the UNO Glacier Creek Preserve Education Center at the Allwine Prairie preserve in Omaha. The plan helped facilitate discussions leading to a donation through the University of Nebraska Foundation for construction of the gardens.

These projects provided hands-on learning opportunities and significant community benefits leading to completed or in-process projects that illustrate creative, practical approaches to successful rain garden, pollinator garden, and sustainable landscape implementation. Rain gardens are also a strong real-world model for STEM-focused curriculum, and proposals are in place to build from these projects to expand rain garden projects for public schools and faculty training.

High school and UNO project personnel continue to participate in rain garden evaluations to learn more about garden function and design. Through a combined effort of the City of Omaha, OPS, and UNO, high school science students are working in water monitoring and assessment of city rain gardens. In addition, a UNO faculty member is helping train an OPS science teacher about rain garden and pollinator habitat design as well as research methods applicable to rain garden assessment that can be integrated into a high school science curriculum.

***Graduate Students***. Three graduate students completed their degrees in conjunction with this project. Degree types, titles, and awarding departments were:

- Master of Science - Horticulture. Hydrologic Effectiveness and Plant Survivability in the Holmes Lake Rain Garden Pilot Program: Year Three Lincoln, Nebraska. Agronomy and Horticulture, UNL (Liebsch 2011).
- Master of Science - Biological Systems Engineering. Hydrologic Evaluation of Established Rain Gardens in Lincoln, Nebraska Using a Storm Runoff Simulator. Biological Systems Engineering, UNL (Anderson 2011).
- Master of Community and Regional Planning. Assessing Impermeable Surface Area Impacts on Modeling: Implications for the Combined Sewer Overflow Long Term Control Plan in Omaha, NE. Community and Regional Planning Program, College of Architecture, UNL (Szatko 2012).

**Research**

***Evaluation of Existing Rain Gardens - Plants and Aesthetics***. A grant-funded cost-share program that began in 2007 supported the installation of 20 rain gardens on residential and school properties in the 3,460 acre Holmes Lake Watershed that drains into Holmes Lake, a 112 acre flood control reservoir in southeastern Lincoln, NE. A graduate student-led assessment of 18 of these gardens during the summer of 2011 focused on plant performance and aesthetics to establish a database standard for successful regional rain gardens. Visual inspections were performed to document the initial street view impression, followed by a summary of noted vegetative and/or hydraulic problems. Lastly, interviews were conducted with 14 of the garden owners to ascertain their thoughts and comments on several topics including: how well the garden was functioning, both hydraulically and aesthetically; if any previous drainage problems had been solved; if their knowledge of rain gardens had been enhanced; and if they had educated others about rain gardens (Liebsch and Rodie 2012).

Revisions by property owners to the original designs caused some compromises in garden success and function. There was a problem with plant survivability of some species in all but three gardens. Issues more closely studied included use of sprinkler systems, hydraulic function, and plant placement within the garden. Plant placement was a major concern relative to survivability. Study results indicated that plant recommendation lists need to be updated to include where a plant will do best within the different areas of a rain garden (i.e., bottom, interior berm sides, top of berm, and berm exterior); and installers need to be further educated on these findings. All 14 garden owners interviewed stated that they had educated others, and 11 indicated that their own knowledge had increased.

***Evaluation of Existing Rain Gardens - Hydrology***. A second graduate student-led investigation was also conducted in the summer of 2011 to evaluate in-situ hydrologic properties of 12 of the Holmes Lake Watershed rain gardens. A unique stormwater

runoff simulator (Franti et al. 2007a; 2007b), was used to apply a volume-based design storm of 1.2 inches (Water Quality Volume) as a 30-minute hydrograph to each garden. Data including ponding zone storage capacity, infiltration rate, time of complete drainage, soil characterization, berm and outlet construction, and bottom grading were collected and analyzed to evaluate performance characteristics (Anderson et al. 2012).

Every rain garden tested drained in 30 hours or less, with six gardens draining in less than one hour, indicating that these 2-4 year old gardens were not limited by infiltration rate, which met or exceeded performance standards. Water storage capacity was poor, with only two gardens able to hold the design storm volume. On average, the rain gardens studied were able to hold only 40% of the design storm volume. Poor basin grading, outflow structure construction and placement, and berm integrity were the primary reasons for the inadequate storage volumes. The results of the testing thus showed that accurate construction, including careful leveling of the garden bottom and berm grading, should be a high priority for rain garden installation.

Findings from both the plant and hydrology focused studies have been incorporated into several college courses and Extension rain garden programming, and used to update design, construction, and management recommendations.

## Summary

A five-year University of Nebraska project strongly integrated extension, teaching, and research to address stormwater management education. Audiences included youth, college students, MS4 community stormwater program managers and residents, Master Gardeners, design and planning professionals, and green industry professionals. Innovative extension activities included: all-day, audience participation rain garden workshops/ installations; an on-line, interactive rain garden animation; and a youth-focused comic-style booklet where the reader can follow the learning adventures of the characters Stormwater Sleuth and Running Rain. Expanded curriculum addressing green infrastructure, low impact development, and stormwater best management practice design resulted in new course lectures for landscape architecture and landscape horticulture students. Studio design projects conceptually addressed real-world clients and stormwater management issues. Research studies evaluated in-situ rain garden hydrologic and plant growth attributes, with findings incorporated into college courses, extension programming, and updated design, construction, and management recommendations. The strong integration of extension, teaching, and research, which is often a significant challenge, is a key to stormwater management programming successes. As a result, communities and individuals are able to more effectively manage stormwater quantity and quality. Future efforts using a STEM-focused approach to illustrate creative, practical approaches to rain garden, pollinator garden, green infrastructure, and sustainable landscape implementation for public schools, municipalities, and other entities are planned, following up on successes of this project.

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# Issues Associated with the Use of Untreated Roadside Springs as a Source of Drinking Water

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**Abstract:** Roadside springs are prevalent across Pennsylvania, but little information has been available about their public use or their suitability as a drinking water source. Penn State Extension conducted research to document roadside spring use and drinking water quality between 2013 and 2015. A survey of over 1,000 Pennsylvania residents found that 30% have consumed water from a roadside spring and 12% consume water every year, mostly because they perceive the water as natural with a good taste. A synoptic survey of 37 springs in 2013-2014 found that more than 90% failed one or more health-based drinking water standards. A more intensive follow-up study in 2014-2015 on ten of the 37 roadside springs found that they consistently failed drinking water standards throughout the year, including some presence of both *Giardia* and *Cryptosporidium* cysts. Total coliform bacteria were found to be a better indicator of the overall microbiological drinking water safety of these springs than *Escherichia coli* bacteria when only a single sample is collected. The frequent use of roadside springs along with poor drinking water quality represent a significant health risk that needs to be addressed in public health education programs.

**Keywords:** *groundwater, education, bacteria, Giardia, Cryptosporidium*

Groundwater springs are common across Pennsylvania accounting for more than 20% of the private household drinking water supplies in many northern and western counties of the state (U.S. Census Bureau 1990). Similarly, roadside springs occur frequently along local and state roads where road cuts have intersected shallow groundwater aquifers. Some roadside springs simply include a road pull-off to access a natural spring while others have been extensively improved to include parking lots, plumbing, and detailed stone walls, all to improve public access for collection of spring water.

Studies of roadside springs are generally lacking, but one Pennsylvania study of household springs found that they were much more likely to have bacterial contamination than drilled or dug water wells (Sharpe et al. 1985). A 1990 report by Pennsylvania state government included basic testing of several popular roadside springs in northeastern Pennsylvania (Pennsylvania General Assembly 1990). The cursory study of these springs concluded that roadside springs may not meet state drinking water standards (PA DEP 2006). The report recommended that a detailed inventory and testing of roadside springs was needed along with educational efforts to assist in curbing risks associated with consumption of drinking water from these unprotected water supplies. Many municipalities and other owners of road right-of-ways responded by installing signs at road springs warning of their unsafe drinking water, but most signs have been defaced or destroyed by visitors to the springs.

In recent years, Penn State Extension water resources specialists have experienced an increased number of referrals from physicians with patients using home or roadside springs. These patients reportedly experienced various gastrointestinal illnesses including giardiasis and cryptosporidiosis. Data from the Pennsylvania Department of Health (2013) also reported that

giardiasis is most prevalent in many of the same counties where household springs are most common (U.S. Census Bureau 1990).

Little research has been done on roadside springs because they are unregulated drinking water sources and their public use is poorly understood. More data on the use of roadside springs along with more detailed water quality data are needed to better quantify the health risks associated with these water supplies and target public education efforts.

Penn State Extension developed a roadside spring project from 2013 to 2015 to gather additional information about roadside springs. The focus of the project was to quantify the following:

1) Drinking water quality from many roadside springs across the state.
2) The approximate public drinking water use of roadside springs.
3) Public awareness about the risks associated with consuming water from untreated roadside springs.

## Methods

### Statewide Roadside Spring Testing

Between April 2013 and May 2014, seven Penn State Extension water resources specialists collected single water samples from 37 roadside springs located in 21 counties across Pennsylvania (Figure 1). The spring locations were focused in western and northern Pennsylvania where trained water resources Extension educators are located and where the density of springs is highest. Project staff also took photos of each spring and noted if other people were present collecting drinking water from each spring. These 37 roadside springs were selected based on recommendations from district offices of the Pennsylvania Department of Transportation and various local government officials who own and maintain road right-of-ways.

Water samples were collected and transported on ice to the Penn State Agricultural Analytical Services Laboratory within 24 hours as required for testing. Eighteen parameters were analyzed including total coliform bacteria, *E. coli* bacteria, pH, total dissolved solids (TDS), nitrate-nitrogen, aluminum, arsenic, barium, copper, lead, iron, manganese, sulfate, chloride, alkalinity, corrosivity index (LSI), total suspended solids (TSS), and hardness using standard methods (APHA, AWWA, WEF 1998). The Penn State water laboratory is accredited by the Pennsylvania Department of Environmental Protection. Sample results below detection limits were converted to 50% of the detection limit for statistical analyses. Bacteria results above the maximum detection limit of 201 colonies per 100 mL were reported as 201 colonies.

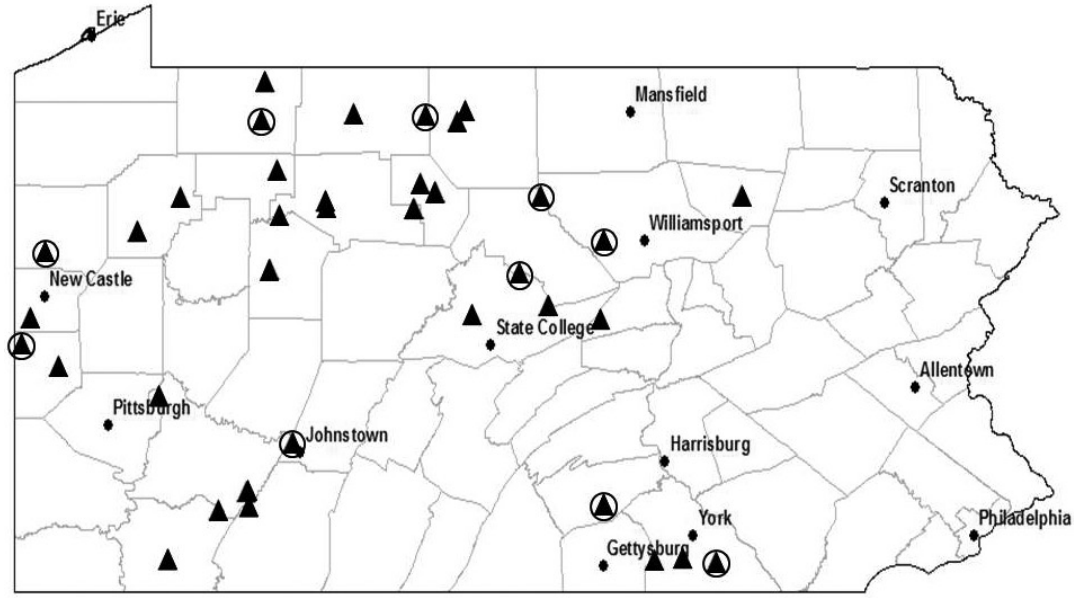


**Figure 1.** Location of the 37 roadside springs sampled once in 2013-2014 (all triangles) and the ten springs that were selected for additional seasonal sampling in 2014-15 (circled triangles).

### Seasonal Roadside Spring Testing

The initial testing identified 12 (32%) of the 37 roadside springs that represented an especially large risk due to the presence of *E. coli* bacteria. From these 12 springs, ten that were most convenient for project staff to sample were selected for more detailed testing between June 2014 and March 2015. The locations of these ten springs are denoted in Figure 1.

Each of these springs were visited by the project staff in June 2014, September 2014, December 2014, and March 2015 to collect water quality samples. All samples were kept on ice and transported to the Penn State Agricultural Analytical Laboratory within 24 hours of collection for analysis of the same chemical and microbiological parameters that were completed in the initial survey. During each sample collection visit, project personnel documented the flow of each roadside spring in gallons per minute (gpm) by measuring the number of minutes required to fill a two to five gallon bucket. The number of visitors collecting drinking water (if any), was also noted during each site visit.

During the March 2015 sample collection visit, an additional sample was collected from eight of the springs for analysis of protozoan (*Giardia* and *Cryptosporidium*) cysts or oocysts. Only eight springs were included in this testing due to cost limitations. These same eight springs were also tested for protozoan cysts in October 2014, but no other water chemistry samples were collected at that time. March and October were selected for protozoan testing to include the typically wettest and driest seasons of the year in Pennsylvania. Samples for cyst enumeration were collected into 10 liter cubitainers and shipped overnight on ice to the Analytical Services laboratory in Williston, Vermont. *Giardia* and *Cryptosporidium* were quantified in each sample using EPA Method 1623.1. This testing included one matrix spike sample for each water sample collected from a source. *Giardia* and *Cryptosporidium* results were reported in cysts or oocysts per liter.

### Roadside Spring Use Survey

Several anonymous survey questions were added to standard evaluations used at various Penn State Extension educational workshops and displays at events in 2014 and 2015 to estimate the statewide use of roadside springs. These workshops focused on rural drinking water, pond management, stormwater, pesticide certification, irrigation management, groundwater education, gardening, or other topics. Attendees were asked two questions including their frequency of roadside spring use and their reasons for using water from roadside springs. Most responses were collected informally using remote electronic response cards incorporated into PowerPoint presentations, or on paper slips.

### Public Outreach

Given the extent of public use of roadside springs, public outreach and extension were an important outcome of this research. Results from the study were compiled into research reports as well as a short fact sheet for distribution to the public at Extension events and through websites. News releases were also prepared for written, online and media outlets. The project investigators presented results from this study at a variety of Penn State Extension water resources workshops, webinars, and events across the state. A short post-program evaluation was provided to all attendees to determine if they learned new information about roadside springs and if they intended on taking actions such as testing of roadside springs or avoiding their use for drinking water. Public outreach did not include the installation of signs at roadside springs due to the past experience with the destruction or removal of signs noted by other agencies and municipalities controlling access to roadside spring sites.

## Results and Discussion

### Statewide Roadside Spring Testing

Water quality in the 37 springs was typical of shallow groundwater in Pennsylvania, characterized by slightly acidic and soft water with low concentrations of most chemical constituents (Table 1). The major aesthetic issue for most springs was corrosive water and low pH which exceeded drinking water standards in 89% and 40%, respectively, of the roadside springs. These would only be a concern if the water was improperly stored in a container capable of

dissolution by corrosive water. Concentrations of other aesthetic pollutants like iron, manganese, sulfate, and chloride were very low in most springs (Table 1) and only rarely exceeded drinking water standards (Figure 2) which would explain the public perception of good tasting water.

Nearly all of the springs contained levels of total coliform bacteria above the health-based safe drinking water standard and 34% contained unsafe levels of *E. coli* bacteria indicating fecal sources of contamination (Figure 2). One spring also contained unsafe levels of lead which may have resulted from corrosion of a metal pipe installed to assist with collection of water. Concentrations of nitrate-N, arsenic, barium and copper were all very low (Table 1) and no springs exceeded safe drinking water standards for these parameters (Figure 2).

**Use of Roadside Springs**

Public use of many roadside springs was apparent during the initial visits to the 37 springs in 2013. People were found collecting drinking water from 10 of the 37 springs (27%) when project staff randomly visited the springs to collect initial water quality samples. The informal survey of attendees at educational workshops provided better information on the overall use of roadside springs.

A total of 1,035 attendees at 56 Penn State Extension workshops in 2014-2015 were asked the two questions about their use of roadside springs. Responses were distributed across the state including northcentral (312), northeast (173), northwest (41), southcentral (287), southeast (156), and southwest (66).

Overall, 30% of the respondents indicated that they had consumed water from a roadside

**Table 1.** Water quality statistics from 37 roadside springs in Pennsylvania (2013-2014). All results are in mg/L except bacteria (colonies per 100 mL), pH, and corrosivity (LSI index).

| Parameter | Mean | Standard Deviation | Minimum | Maximum | MCL* | Type of MCL |
|---|---|---|---|---|---|---|
| Coliform bacteria | 83.5 | 14.2 | <1 | >201 | <1 | Health |
| *E. coli* bacteria | 7.8 | 5.7 | <1 | >201 | <1 | Health |
| Arsenic | <0.003 | 0 | <0.003 | <0.003 | <0.010 | Health |
| Barium | 0.0297 | 0.0035 | 0.0069 | 0.0858 | <2.0 | Health |
| Lead | 0.0034 | 0.0019 | <0.003 | 0.0678 | <0.015 | Health |
| Nitrate-N | 0.81 | 0.24 | <0.50 | 6.168 | <10.0 | Health |
| Copper | 0.0030 | 0.0004 | <0.005 | 0.0120 | <1.0 | Health |
| pH | 6.78 | 0.14 | 5.06 | 7.88 | 6.5 to 8.5 | Aesthetic |
| TDS | 102.2 | 30.5 | 20 | 866 | <500 | Aesthetic |
| Chloride | 13.6 | 6.9 | <5.0 | 239.9 | <250 | Aesthetic |
| Sulfate | 21.1 | 8.5 | 0.451 | 292.1 | <250 | Aesthetic |
| Iron | 0.045 | 0.014 | <0.05 | 0.416 | <0.30 | Aesthetic |
| Manganese | 0.011 | 0.003 | <0.001 | 0.101 | <0.05 | Aesthetic |
| Corrosivity | -2.39 | 0.28 | -5.46 | 0.98 | Non-corrosive | Aesthetic |
| Aluminum | 0.03 | 0.01 | <0.01 | 0.22 | <0.20 | Aesthetic |
| Alkalinity | 42.1 | 11.2 | 1.9 | 263.4 | - | None |
| TSS | 0.70 | 0.19 | 0 | 4 | - | None |
| Hardness | 63.5 | 21.9 | 5.2 | 663.7 | - | None |

*Maximum Contaminant Level (MCL) = state drinking water standard (PA DEP, 2006). Aesthetic standards are set for taste, smell, staining, residues, corrosion, etc.

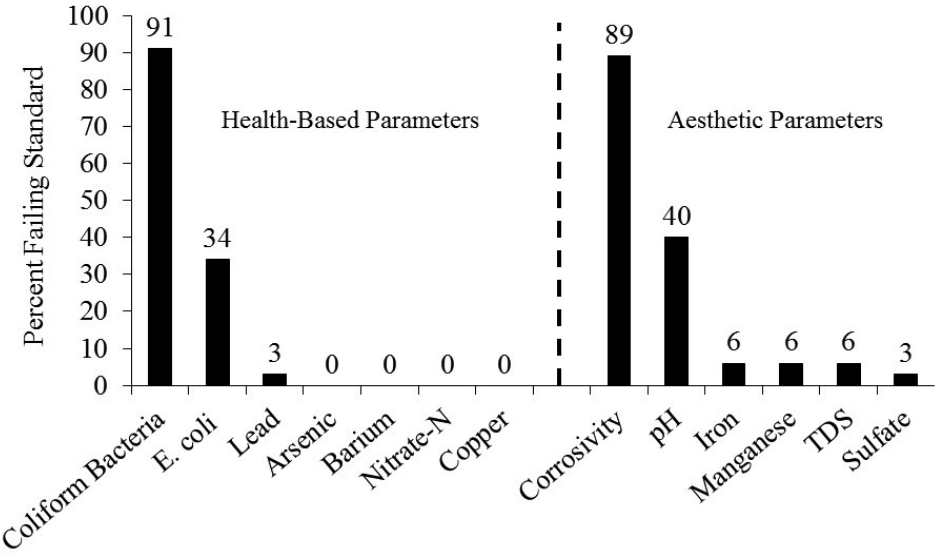


**Figure 2.** Percent of 37 roadside springs that failed to meet various health-based and aesthetic drinking water standards.

spring at least once in their lifetime, while 69% had never consumed roadside spring water. The remaining 1% gave no response. Of the 30% who had consumed roadside spring water, 18% collected water infrequently (12% every few years, 6% annually), while 12% collected spring water regularly (4% every few months, 5% monthly and 3% weekly).

The most common reasons for consuming water from roadside springs cited by respondents were the perceived "natural" condition of the water (42%) and the good taste of the water (41%). Other reasons for using roadside spring water included the proximity of a spring to a camp or seasonal home (20%), the overall convenience of accessing a roadside spring (12%), and as a replacement for their contaminated home drinking water (10%). An additional 15% of respondents indicated "other" uses for roadside spring water including water for household or garden plants, water for aquariums, and drinking water while hiking or biking.

**Seasonal Roadside Spring Testing**

Seasonal water quality among the ten roadside springs was consistent (Table 2) and agreed with the overall data from the larger set of 37 springs tested in 2013 (Table 1). Stable water quality across seasons agreed with the relatively constant flows which were typically less than 10 gpm in each spring (Table 2). More importantly, the safety of roadside springs as drinking water sources was found to be consistently poor across all four sampling periods as evidenced by the percent that exceeded various drinking water standards (Table 2). Coliform bacteria and *E. coli* bacteria were the most prevalent drinking water problems found in the springs. Higher bacteria concentrations were generally observed in March and June, presumably due to wetter and warmer conditions promoting surface water infiltration into roadside springs. Counts of coliform bacteria in roadside springs were highest in June 2014, then declined though fall and winter before beginning to increase again in March 2015.

Results from the two samples collected in October 2014 and March 2015 from eight of the roadside springs for enumeration of protozoan cysts are shown in Table 3. Seven of the eight springs (88%) contained *Giardia* cysts or *Cryptosporidium* oocysts during one or both of the sample times, but the concentrations of cysts were generally low (below 10 per liter). It is important to note that the presence of *Giardia* cysts and *Cryptosporidium* oocysts reported may overestimate the general occurrence in most roadside springs since these sites were specifically selected for testing based on the prior occurrence of *E. coli* bacteria. Data analysis shows that the hypothesis that *E. coli* bacteria may indicate a higher risk of protozoan parasites in roadside springs is questionable.

**Table 2.** Mean water quality concentrations in ten roadside springs in each season. All results are in mg/L except flow (gallons per minute), bacteria (colonies per 100 mL), pH, and corrosivity (LSI index). Percentages indicate the percent of springs that failed drinking water standards where applicable.

| Parameter | June 2014 | September 2014 | December 2014 | March 2015 |
|---|---|---|---|---|
| Flow (gpm) | 9.5 | 3.4 | 5.3 | 10.4 |
| Coliform bacteria | >201 (100%) | 169 (100%) | 87 (100%) | 110 (100%) |
| *E. coli* bacteria | 20 (50%) | 19 (50%) | 1 (30%) | 5 (40%) |
| Arsenic | <0.003 | <0.003 | <0.003 | <0.003 |
| Barium | 0.018 | 0.018 | 0.016 | 0.017 |
| Lead | 0.002 | 0.001 | 0.001 | 0.001 |
| Nitrate-N | 0.91 | 0.77 | 0.93 | 0.95 |
| Copper | <0.005 | <0.005 | <0.005 | <0.005 |
| pH | 6.85 (20%) | 7.12 (10%) | 6.99 (30%) | 7.14 (10%) |
| TDS | 117 (10%) | 144 (10%) | 125 (10%) | 118 (10%) |
| Chloride | 11.4 | 12.2 | 10.8 | 10.8 |
| Sulfate | 39.7 (10%) | 48.1 (10%) | 44.8 (10%) | 35.3 (10%) |
| Iron | 0.10 (10%) | 0.07 (10%) | 0.08 (10%) | 0.10 (10%) |
| Manganese | 0.003 | 0.003 | 0.003 | 0.003 |
| Corrosivity | -2.2 (80%) | -1.74 (80%) | -1.97 (80%) | -1.82 (80%) |
| Aluminum | 0.05 | 0.03 | 0.04 | 0.10 (20%) |
| Alkalinity | 43 | 54 | 50 | 44 |
| TSS | 2 | 1 | 2.1 | 1.7 |
| Hardness | 83 | 102 | 94 | 76 |

Coliform and *E. coli* bacteria results from the March 2015 sample were compared since they were collected at the same time as the March protozoan samples. While coliform bacteria were present in all samples in large numbers and were generally higher in springs that contained protozoan cysts, *E. coli* bacteria were absent from several springs that contained protozoan oocysts (Table 3). Conversely, several springs that had protozoans during both sample time periods did not test positive for *E. coli* bacteria and the one spring that did not have protozoans during either sample period did test positive for *E. coli* bacteria (Table 3). Further comparison of protozoan results to bacteria results from the entire year produced similarly confusing results. The Warren County spring that contained protozoan cysts but no *E. coli* during March 2015 tested positive for *E. coli* in all prior sample periods. However, the Centre County spring which was the only spring to not test positive for protozoans in either sample, tested positive for *E. coli* in 80% of samples from the spring, with values as high as 165 colonies per 100 mL. These results generally agree with Wilkes et al. (2009) who found that relationships between indicator bacteria like *E. coli* and parasite oocysts/cysts were overall weak and site specific.

Water testing for *Giardia* and *Cryptosporidium* is prohibitively expensive for the public making correlations to a less-expensive and widely available water quality indicator critical. While *E. coli* is a good indicator of bacterial safety of drinking water, it appears to be a poor indicator of the presence of protozoan parasites in roadside springs. Coliform bacteria were a stronger indicator of protozoan cyst presence, but these bacteria were also present in significant numbers in all springs. Even though *E. coli* bacteria was a

**Table 3.** *Giardia* cyst and *Cryptosporidium* oocyst occurrence (cysts or oocysts per L) in samples collected from eight roadside springs in October 2014 and March 2015 in comparison to bacteria concentrations in March 2015.

| | October 2014 | | March 2015 | | | |
|---|---|---|---|---|---|---|
| **County Location of Spring** | ***Giardia*** | ***Cryptosporidium*** | ***Giardia*** | ***Cryptosporidium*** | **Coliform bacteria (#/100 mL)** | ***E. coli* bacteria (#/100 mL)** |
| Lycoming | 5.28 | 5.01 | 0.09 | 0 | 62 | 0 |
| Centre | 0 | 0 | 0 | 0 | 59 | 5 |
| McKean | 0 | 0 | 6.49 | 2.23 | >201 | 0 |
| York | 5.7 | 6.36 | 0 | 0 | >201 | 0 |
| Beaver | 0 | 0 | 6.29 | 4.26 | >201 | 8 |
| Warren | 4.07 | 4.71 | 6.75 | 6.93 | 50 | 0 |
| Cambria | 6.32 | 6.05 | 0 | 0 | 32 | 2 |
| Cumberland | 0 | 0 | 6.82 | 5.57 | >201 | 0 |

poor indicator of protozoan cysts in single samples collected in March 2015, more research is needed to determine if springs that never test positive for *E. coli* can still contain protozoan cysts.

### Public Outreach

The results from this study have important health implications for residents collecting drinking water from untreated roadside springs. The research results were distilled into a short website and fact sheet (http://extension.psu.edu/natural-resources/water/drinking-water/cisterns-and-springs/roadside-springs) for the public which has had 780 website visits in just four months. Project investigators also presented the research results to 1,619 attendees at 56 different extension programs. Educational programs were also targeted to important stakeholders including township road managers and public health officials. Of the 1,619 total attendees, 887 (55%) participated in a survey and 845 (95%) indicated that they had learned new information about roadside springs. More importantly, 690 (78%) were planning on taking some action to change their use of roadside spring water.

In addition to workshop presentations, project investigators prepared various news releases which were widely carried by newspapers and radio stations across the state. A statewide webinar on the project was also presented live or via recording to 253 participants. The recorded webinar and supporting materials can be viewed at http://extension.psu.edu/natural-resources/water/webinar-series/past-webinars/a-study-of-roadside-springs-in-pennsylvania.

## Summary and Conclusions

Results from this study show that roadside springs are a routine source of drinking water for about 10% of the rural Pennsylvania population. Another 20% indicated that they use roadside springs occasionally for drinking water. Consumers of roadside springs most often point to perceived natural pureness and good taste as the main reasons for collecting spring water. While roadside springs generally provided aesthetically pleasing drinking water, nearly all fail health-based drinking water standards and many contain *E. coli* bacteria and/or parasitic *Giardia* cysts and *Cryptosporidium* oocysts. All springs containing parasitic cysts contained at least 32 colonies of total coliform bacteria per 100 mL, but *E. coli* was found to be a poor indicator of the presence of parasitic protozoans when only a single sample is collected. Temporal variations in both *E. coli* and protozoan cyst concentrations in individual springs showed that single instances, where they were absent, did not ensure those organisms are absent year round.

These results suggest that untreated roadside springs can present a significant health risk and

are largely unsuitable as drinking water sources. Total coliform bacteria appear to be the most conservative indicator of drinking water quality in roadside springs. Residents considering the use of a roadside spring for drinking water or other household purposes should, at a minimum, have the water tested through a state accredited laboratory for total coliform bacteria to ensure its safety, bearing in mind that microbial quality varies over time. In addition to bacteria problems, most roadside springs had slightly soft and acidic water, a combination that produces corrosive water that is aggressive toward metals and other materials. Because most roadside springs have very corrosive water, it is critical that this water only be stored in containers approved for drinking water storage.

Given the prevalence and rural location of many roadside springs along with the associated health risks, this project dedicated significant resources to ensure public education including online resources, workshops, and news media. More research and outreach impact analyses are needed in areas of Pennsylvania where roadside springs are commonly used as drinking water sources and structures such as pipes may give the illusion of a safe water supply. The results may be applicable in other states with similar groundwater geology and usage of roadside springs.

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# Developing Capacity for Local Watershed Management: Essential Leadership Skills and Training Approaches

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**Abstract:** Management of water resources at a watershed scale often occurs at the local level and relies on the effectiveness of local staff and leaders. Four land-grant universities in Indiana, Michigan, Minnesota and Ohio are delivering training programs that build the capacity of local water resource professionals. Based on experience from these programs, a survey on watershed management core competencies, and two surveys of information and training needs for watershed groups, we examined what core proficiencies are needed by watershed group leaders, how existing programs have approached professional training, and effective methods for delivering the training. Results indicated that successful watershed leaders said they must have skills in leadership, communication, collaboration, technology, policy, and planning along with a solid understanding of natural science disciplines. More importantly, they must be able to integrate these skills to solve problems. The mode of delivery (distance or in-person) depended on the audience and training goals, emphasized networking opportunities with the instructor and other participants, and encouraged participants to apply lessons to their own situations. Features of a successful training program that effectively build watershed leadership capacity are provided.

**Keywords:** *distance learning, natural resources, education, Extension, training, professional development*

Local watershed organizations can play a leading role in collaborative water resource management in the U.S. by addressing nonpoint sources of water pollution, such as agricultural and urban stormwater runoff, and other management issues (Leach and Pelkey 2001; National Research Council 1999; Sabatier et al. 2005). A diversity of skills and knowledge is essential to being an effective leader of watershed management. Much of the literature on collaborative watershed management emphasizes the critical social skills. In a study of six watersheds, Imperial (2005) found that leadership, staffing and recruitment, personnel management, budgeting, contracting, and grants management were important factors influencing collaborative activities. Leadership and social sciences skills were found to play a key role by Allen and Kilvington (2005) and McGuire (2006), who organized the major collaborative management skills into activation, framing, mobilizing, and synthesizing. Imperial and Hennessey (2000) emphasized the need to understand the "ecology of governance" in addition to understanding how (natural) ecological systems function. They emphasized the need for interpersonal and facilitation skills to resolve disputes and broker agreements, political skills to avoid conflicts, and leadership, argument, and persuasion skills to help leaders engage willing volunteers in collaborative processes such as watershed management.

One reason that social and leadership skills are often emphasized in studies of collaborative watershed management may be that a natural science background and technical skills are presumed to be common for watershed managers, not that technical skills are unimportant. A fundamental understanding of natural sciences such as hydrology, stream and lake ecology, invasive species, and stream dynamics are

important for effective watershed management. A survey of 600 water resource managers by Bourget (2006) found that while respondents emphasized the need for interdisciplinary skills, the top needs selected were watershed hydrology and modeling, followed by geographic information systems. One respondent commented that "There are far too many generalists that are emerging who lack sound scientific skills and experience." Few individuals possess all the natural science and technical skills that are important for effective watershed management.

Building the capacity of water resource leaders requires higher level learning including analysis, synthesis, and evaluation (Bloom et al. 1956), and specifically, the ability to integrate multiple physical and social science disciplines to address complex water resource challenges. No one individual can have a deep understanding of all these areas. Uhlenbrook and Jong (2012) discussed a "T-shaped competency profile" for water professionals that combines deep competency in a specific field (the leg of the T) with a broad suite of interdisciplinary and personal competencies (the crossbar of the T). This forms the basis for higher education of water professionals described by McIntosh and Taylor (2013), which although more in-depth for the post-graduate program they describe, could also be a helpful model for watershed management education.

Several land grant universities in the Great Lakes region have developed educational programs to increase the capacity of watershed groups and their leaders in developing and implementing watershed and lake management plans. This paper takes a critical look at four watershed training programs developed by Purdue University, Michigan State University, University of Minnesota, and The Ohio State University. We first provide an overview of the four programs, including a comparison of content, structure, and delivery methods. To identify educational needs of watershed and lake management leaders, we report on a survey conducted with watershed and lake management program participants to identify knowledge and skill areas associated with effective watershed management leadership. This is followed by a more detailed comparison of the content of the four programs focusing on the balance between social science and natural science topics. We then focus on delivery methods and discuss the relative merits of distance education and in-person approaches. Lastly, we provide conclusions with a focus on providing practical information to watershed management practitioners to inform the development and delivery of similar programs in other states.

## Overview of Four Watershed Leadership Programs

Four watershed leadership training programs were compared to evaluate diverse delivery methods, types of participants, motivation for participation, content of the programs, participant activities, program evaluation, and funding mechanisms. The four programs (and year of initiation) are the Indiana Watershed Leadership Academy (2006), the Michigan Lake and Stream Leaders Institute (2002), the Minnesota Watershed Specialist Training (2013), and the Ohio Watershed Academy (2001). Each program was designed to meet the needs of their targeted audiences within each state.

Both the Ohio and the Minnesota programs are online only. The Ohio program is a 10-week program while Minnesota's lasts 14 weeks with optional weekly web/phone meetings. Indiana's Academy is a blended training program, consisting of three face-to-face class sessions and a series of web-based distance learning modules offered over a five month period. The Michigan program is delivered entirely face-to-face, with five all day sessions offered over the course of six months. In alternate years, a one day face-to-face advanced class is offered for alumni.

Target audiences vary somewhat within each state but all include water resource professionals and volunteers, especially those who are directly involved in developing and implementing local watershed action plans. Other targeted groups include community leaders, people representing watershed and non-profit organizations, local and state government officials, teachers, students, and retirees. The number of attendees per class ranges from 15 to 30 participants. A challenge faced by all programs is the vast difference in background, knowledge, and interests of attendees

on the various topics covered including watershed management, hydrology, biology, policy, planning, communications, and social science.

Based on mail surveys and direct evaluations by program attendees, many participants indicated that they are primarily motivated by a desire for professional or personal development. People who complete any of the programs earn either a Professional Certificate in Watershed Management or a Certificate of Completion. Minnesota and Ohio also offer the option of university credit. Other motivating factors cited by participants in evaluations include interest in lake and stream ecosystems, leadership, institutions and legal frameworks, identifying and involving partners, negotiation skills, or building the broad package of skills. In Ohio, the state Department of Natural Resources (ODNR) required the training for ODNR-funded watershed coordinators.

Each program incorporates homework assignments, required readings, and discussion with peers (online or face-to-face). Two of the programs also require an independent group or individual project. Examples of assignments include writing a strategic communication plan, designing a gap exercise to identify information needs, planning a stakeholder analysis or community assessment, preparing a photo essay of a community watershed issue, and calculating pollutant loads using monitoring data. Both the online and face-to-face approaches promote networking and introduce participants to water management practices.

Each program includes an evaluation component that includes a participant self-assessment of learning. Evaluation responses also provide feedback to instructors about participants' confidence in watershed planning, implementation and leadership, and their opinions on the relevance of presented topics. Participants provide their assessment of the entire program including their likes and dislikes. These evaluations help the instructors shape their programs for the future and determine if they are meeting their goals.

Participant fees range from $125 to $825 per person, or more if students are paying university tuition. However, the real cost of delivering training is estimated to be $850 per person in Minnesota and $2200 per person in Indiana, where expenses include overnight accommodations and meals. Expenses not covered by fees are paid by a variety of sources, including private donations, state funding, federal grants, and in-kind contributions of time from instructors.

These four programs cover some of the same topics as the Environmental Protection Agency's Watershed Academy Web (EPA 2015), an online self-administered certificate program. Unlike EPA's academy, these programs provide substantial time for networking and interaction among participants, either online or in-person, and provide a local and state-specific perspective.

## Skills and Knowledge of an Effective Watershed Leader

In 2013, our team conducted an online survey of individuals who had previously participated in any one of three watershed leadership training programs offered by The Ohio State University, Michigan State University or Purdue University (Bonnell and Baird 2013). At the time, Minnesota's program was in its first year. The purpose of the survey was to gather input on the value of these training programs; to identify core competencies required by leaders of watershed, lake, and stream management efforts; and to evaluate the extent to which the programs were addressing the identified core competencies. Invitations were sent to 445 program participants, and 117 responded to the survey. Respondents were asked to rate the degree to which each knowledge/skill "item" was critical to their work (Table 1). Respondents were also given the option to write in "other" items under each category. Of the 26 items listed, 19 were rated as being critical or very critical. The ten highest rated items, with number 1 being highest, were: 1) Partnerships and collaboration; 2) Outreach and communication; 3) Project management; 4) Landowner interactions and interpersonal skills; 5) Best management practices; 6) Building professional networks; 7) Strategic planning; 8) Water quality criteria; 9) Working with boards and volunteers; and 10) State regulations.

Survey respondents were also asked to list up to five competencies (knowledge, skills, abilities, or behaviors) that have proven to be most beneficial or made the biggest difference for them in their role in water resources management. Their open-ended

**Table 1.** Knowledge/Skill Areas Included in Survey of Watershed Academy Participants.

| | |
|---|---|
| **Organizational** | Strategic planning<br>Facilitation<br>Fundraising<br>Partnerships/Collaboration<br>Working with boards and volunteers |
| **Interpersonal** | Negotiation<br>Conflict management<br>Building professional networks<br>Project management |
| **Ecological assessment** | Water quality criteria<br>Monitoring<br>Hydrology/stream processes<br>Designing scientific studies |
| **Implementation** | Restoration design<br>Best management practices<br>Landowner interaction/interpersonal skills<br>Load reduction modeling |
| **Policy** | Water policy<br>Conservation programs<br>Storm water regulations<br>Land use policies<br>Local ordinances<br>State regulations |
| **Education and outreach** | Target audience analysis<br>Program design and implementation<br>Outreach and communication |

comments were grouped into the following five thematic areas based on standard content analysis techniques and a qualitative analysis by a team of evaluation experts:

1. Effective communication (e.g., "speaking to the people you are meeting with at the time and tailoring the message")
2. Organizational and project management skills (e.g., "keeping meetings meaningful and people involved")
3. Facilitative leadership (e.g., "being able to let others have the idea and then support them")
4. Vision (e.g., "an ability to set attainable and measurable goals for which continued progress can be shown to stakeholders, partners, the public, board members")
5. Collaboration (e.g., "maintaining and keeping open strong/trusting relationships with key organizations [such as the] drain commissioner, conservation district, and local interest groups")

These competencies closely matched the top five critical knowledge/skill areas, providing confirmation of the importance of these categories

of knowledge and skills to effective watershed leadership.

This research effort allowed for the identification of core competencies that watershed and lake management leaders considered fundamental to their success and identified some of the benefits and areas for improvement in our respective watershed leadership programs. The most beneficial aspects of the existing watershed and lake management programs for participants are fostering a broader understanding of watershed management and expanding professional networks. In terms of weaknesses, respondents mentioned the need for more applied learning experiences (e.g., case studies and field scale problem solving) and inclusion of additional technical topics, such as calculating load reductions, inventorying streams or identifying aquatic organisms.

## Determining the Curriculum for the Watershed Academies

The selection of a manageable number of topics to address in each of the four programs was challenging because so many skills are needed. To guide development of the curriculum, each watershed program convened an advisory committee made up of University staff and faculty, Extension educators, state agency representatives, and in some cases, nonprofit organizations. In Indiana, a needs assessment and survey were developed with a group of advisors (Broussard et al. 2006), and many ideas were adopted from the Ohio Watershed Academy.

The curriculum development processes in all four states identified a need for both social skills such as leadership and communication, and technical skills such as understanding of hydrology and modeling. However, the balance between these types of skills in each state was based on the following assessments:

1. The Indiana needs assessment survey (Broussard et al. 2006) found that the top four skills identified by watershed management leaders were technical or natural science based: 1) calculating load reductions for possible treatment alternatives, 2) using watershed models to estimate runoff, 3) using GIS to map and analyze watersheds, and 4) identifying restoration alternatives to address watershed problems.
2. In Michigan, the key training skills identified by the advisory team included a basic understanding of aquatic ecology; familiarity with management options, legal frameworks, and resources for partnership, funding, and support; and strong leadership, facilitation and communication skills.
3. In Minnesota, the advisory committee considered the characteristics of effective watershed leaders and then selected training topics based on two criteria: gaps in existing training, and topics of broad need. Several important technical topics (e.g., specific watershed models) were not included in the training because individual needs would vary too much and other training opportunities were available.
4. In Ohio, instructional module topics were determined in part through input from the advisory committee and, over time, feedback from participants. The resulting balance of topics is weighted more heavily on social science knowledge/skills than technical knowledge/skills. A recent study conducted by OSU which included interviewing 20 watershed leaders found that the essential skills most frequently mentioned were communication and interpersonal skills, followed by the ability to recognize and understand community dynamics, confirming the importance of social skills.

The results of each state's program development process are shown in Table 2, listing the major categories of program content along with topics offered by each.

## Integrating Disciplines

Whether a particular module or assignment is primarily grounded in the natural or social sciences, instructors should strive to integrate natural and social science knowledge and skills. For example, a lesson on hydrology and stream function should include linkages to watershed management, which might focus on the identification of critical areas and how stream functions relate to the critical areas.

**Table 2**. Major Content Categories and Topics for the Four Watershed Training Programs.

| Topics | Michigan State University Lake and Stream Leaders Institute | Purdue University Indiana Watershed Leadership Program | The Ohio State University Ohio Watershed Academy | University of Minnesota Watershed Specialist Training |
|---|---|---|---|---|
| **People, Leadership, Communication** | Communicating scientific information, conflict resolution, collaborating and guiding groups to consensus, building powerful partnerships, engaging public participation in natural resources management | Stakeholder involvement, developing effective messages, sustaining watershed groups financially, effective outreach using social marketing strategies, running effective meetings, group facilitation skills | Facilitating group decision making, running effective meetings, stakeholder involvement using social indicators to effectively target watershed education programs, basic negotiation skills | Communication (writing a strategic communication plan), civic engagement, project management (writing a work plan), professional development plans |
| **Technology and Tools** | Water quality assessments, monitoring, wetland identification | Online tools for watershed inventory, gathering social information about your watershed, GIS, calculating loads | Tools to determine how healthy a watershed is, data collection with a purpose, streams dynamic equilibrium, calculating sediment load | Watershed science assessment, monitoring and evaluation |
| **Natural Science** | Ecology of plants, invertebrates, and fish, stream and lake ecology, invasive species, wetlands, bio-engineered and natural shorelines and stream banks | Understanding stream processes, macroinvertebrate monitoring, watershed inventory and analysis | Streams dynamic equilibrium | Watershed science, basic hydrology and limnology, identifying critical source areas |
| **Policy and Regulations** | Michigan inland water law - key concepts and current issues, understanding water withdrawal and use regulations | Understanding the land use planning process, The Clean Water Act: overview, permits, WQ standards and TMDLs, understanding drainage policy and practice | Using Ohio EPA reports to understand water quality and causes of impairment in a watershed | Policy and institutions (who are the players and what are their roles and authority) |
| **Planning** | Developing a watershed management plan, developing a basic/"first order" lake management plan | Gathering social information about your watershed, setting goals to achieve outcomes | Watershed planning and implementation, defining watershed problems, developing goals and objectives, implementing a watershed plan | Project and program implementation, evaluating implementation alternatives (including cost-benefit analysis) |

Tools such as geographic information systems have particular relevance when participants see how maps can be used as an educational tool to aid decision-making.

Both the literature and our program evaluations suggest that strong watershed management coordinators have an ability to integrate natural science tools and information with social skills to inform water resource management. The most effective coordinators are able to act as a bridge between technical experts and people who can get things done in the watershed. They are able to determine what information is needed and translate natural science into terminology that decision makers understand. Macleod et al. (2007) suggested that the set of qualities required to achieve integration include curiosity, confidence, credibility, capacity, communication, collaboration and connections. These qualities are not easily taught, but are a desired outcome of the integrated watershed programs described in this paper. The integrated watershed training program, consisting of both natural sciences and social and leadership skills, mirrors integrated watershed management, focusing on understanding the complexities of water resources and how the pieces fit together.

## Distance vs. In-Person Modes of Program Delivery

Numerous studies have demonstrated that online and face-to-face teaching modes can be equally effective in achieving learning objectives (McCann 2007; Means et al. 2009; Tallent-Runnels et al. 2006, Neuhauser 2002). In both cases, results depend on fundamental principles of teaching and learning. As with face-to-face delivery, effectiveness of distance modes depends on incorporating opportunities for learners to interact with the content, the instructor, and other learners (Mandernach et al. 2009; McCann 2007; Neuhauser 2002). Success with distance learning depends to a large extent on attributes of the learner, emphasizing the importance of selecting and preparing the right learners. Successful distance learners tend to have an internal locus of control (Stone 1992), to be more abstract learners (Ouzts 2006) and to have distinctive learning style preferences (Aragon et al. 2002). Social skills are less essential in determining learning success in an online environment (Pugliese 1994). Little research exists specific to distance training modes for adult professionals studying natural resource topics and for higher order learning objectives.

Each learning mode has different strengths. Distance approaches have the advantage of flexibility and lower travel costs for participants, making them accessible to more participants. Face-to-face modes have the advantage of interpersonal interaction with both instructors and colleagues. Therefore, the choice of mode depends on which of these strengths is most important for the particular audience and training goals.

Generally, in-person learning methods may include field and classroom activities such as lectures, discussions, small group work, hands-on data collection, independent (outside of class) projects, and student presentations. Distance learning methods are predominantly online, including readings and multimedia learning resources, webinars and teleconferences, online discussion forums, and independent projects. Distance methods may be either synchronous (e.g., live webinars) or asynchronous (e.g., discussion boards), and learners may participate either independently or interactively with other participants. All three distance programs discussed here are delivered interactively. Learners go through the programs as a cohort on a set schedule and interact with one another.

Blended education modes that combine distance and in-person modes are increasingly common (Porter et al. 2014). The Indiana Watershed Leadership Academy uses a blended approach, requiring participants to complete online modules and attend in-person workshops. All four programs provide online resources and require independent work including readings, field practice activities, or writing assignments.

The choice of learning mode is based on how well the mode matches the audience and the learning objectives. Computer-based learning is only appropriate if the target audience is technologically savvy and has access to adequate technology. Watershed professionals generally meet these criteria. Volunteers and others learning from home – especially in rural areas – may not have adequate hardware or internet connections for convenient

access to online resources. The learning objectives, rather than the topic, determine which teaching mode is appropriate. For example, the topic of an Index of Biotic Integrity (IBI) can be learned using distance modes if the objective is for students to be able to define an IBI and its components. However, in-person modes are needed if the objective is for students to be able to correctly collect the data to calculate an IBI.

Table 3 lists learning objectives and teaching activities that are suited to distance or in-person methods. Regarding one-way presentations, basic concepts can be delivered effectively at a distance through readings, recorded lectures, field videos, and so on. However, delivery of complex concepts can benefit from an in-person demonstration or an involved Q&A session with instructors.

This difference between basic and complex concepts was revealed during a group evaluation discussion for the Indiana Watershed Leadership Academy. During the evaluation session, participants were asked to identify Academy activities that helped them learn, note whether these were in-person or distance activities, and then discuss whether the lesson could have been learned using the alternate (distance or in-person) type of activity. The outcome of the evaluation session was a group consensus arising from the discussion. Regarding learning web-based tools such as GIS and soils databases, participants saw a need to practice and spend time on their own, but they saw how a brief in-person introduction could be useful for less experienced users. Participants thought in-person contact with instructors would have helped them with difficult concepts such as load reductions; conversely, they liked web meetings because participants could ask more questions. They valued the group problem solving involved with in-person activities such as role playing a planning meeting, identifying stakeholders, and determining Best Management Practices (BMPs) for an example watershed. Finally, participants appreciated the convenience of not traveling for distance learning activities; while conversely, they appreciated the convenience of in-person communication for facilitating group projects.

Networking is an especially critical skill in a complicated and dynamic field like water resource management. Ohio Watershed Academy evaluations documented the value of in-person contact for networking. In the initial course design, participants were required to complete both online and face-to-face components, but the in-person requirement was gradually reduced and then eliminated in 2011. During years when face-to-face workshops were part of the curriculum, participants gave very positive feedback about networking opportunities and noted them in the summative evaluations as one of the most valuable aspects of the program. After the workshops were eliminated, participants gave the course lower ratings on "helping them develop new professional relationships." In the Michigan program, which is delivered entirely in-person, networking with

**Table 3.** Strengths of In-person and Distance Modes of Teaching.

| In-person | Distance |
|---|---|
| • Delivering complex concepts<br>• Role play (e.g., Watershed Game, facilitation skills, Land Use Planning Commission meeting)<br>• Interactive reflection on application of principles (e.g., discussions following case study presentations or role play)<br>• Co-learning (e.g., brainstorming or group problem solving)<br>• Hands-on training and practice of field activities<br>• Networking and interpersonal contact | • Delivering straight-forward concepts<br>• Independent learning pace<br>• Extended discussions with more contributors<br>• Independent selection of learning topics and assignments<br>• Independently applying lessons to a local watershed<br>• Using online tools and resources<br>• Interacting with participants from a wide geographic area |

peers and topic experts, and group interaction, were noted as important components in the comment section of course evaluations. In the Minnesota program, surveys of alumni have been designed to learn whether online activities promote networking. The assumption is that learners who establish professional connections through distance interactions will then build on them at field days, conferences, trainings or other in-person events that occur regularly in the water resource community.

## Effective Delivery Methods

Regardless of the teaching mode, an overriding consideration for effectively training watershed leaders is to address the diverse needs of participants who have educational backgrounds ranging from the natural sciences to the social sciences, work in small rural offices or large urban offices, draw from years of experience or have recently graduated, and face varied priorities in their workplace. In addition, an effective training program will address the constraints inherent to the selected in-person or distance mode. Above all, effective training begins with fundamental principles of pedagogy, or andragogy, in the case of adults (Knowles 1998). Kelly (2013) identified five practices to improve online courses that are equally appropriate to in-person modes of watershed professional training: flexibility, relevance, presence, feedback, and early alerts. All of these practices address the issue of diversity of learners by giving them some control over how and what they learn.

### Flexibility

To meet individual needs, the Ohio, Indiana and Minnesota programs allow learners to either select electives from a menu of optional modules, or select subtopics within a module. Assignments are designed to be flexible to match the learner's level of expertise on the topic. Distance learning is conducive to a flexible time schedule. Ohio and Minnesota have no required synchronous activities; webinars are recorded so participants can listen to them later. Postings to online discussion forums can be made any time within a specified period. All the programs provide some leniency on assignment deadlines acknowledging that participants are juggling other priorities.

### Relevancy and Hands-on Learning

Keeping material relevant to participants is an important characteristic of effective adult learning. Relevancy is enhanced by designing flexible assignments that give students a choice of focus, and by building the course content around practical lessons and concerns of the target audience. Assignments in all four programs encourage participants to apply lessons to examples from their own situation and interests. Relevancy is also enhanced by using active, experiential learning approaches to maintain interest and help participants internalize concepts. Michigan and Indiana provide in-field lessons and role playing activities. Other programs require independent hands-on practice such as completing a watershed assessment.

### Presence and Feedback

Frequent interaction between a learner, the instructors, classmates, and colleagues has three benefits: learners build professional networks, they get feedback from others in the field, and it creates accountability. Interaction among classmates takes advantage of the diverse backgrounds of the learners, turning the challenge of diversity into a learning tool. The Indiana program engages alumni to provide feedback on assignments. The Minnesota program requires participants to provide feedback to other participants. In end-of-session evaluations, participants value the practical feedback from real practitioners in the field of water resource management – both instructors and fellow classmates. Michigan participants valued the in-person interaction with the experts who presented or participated in panel discussions. All four programs encourage interaction with colleagues and community members outside of the course to complete assignments.

### Early Alerts and Learning Guidance

Online learning is challenging not only because of the distance, but because it is asynchronous, which can leave participants feeling isolated and unmotivated. Several strategies can be used to counter this, including explicitly talking about the

challenges of online learning, suggesting strategies for learning, and providing practice interacting in the online environment. Assignments for both online and in person learning can be designed with clear sub-tasks and frequent due dates to help participants manage their time. Students can be made accountable to others by requiring them to share their work and provide feedback on others' work. Monitoring participant activity helps identify and check in with those who are lagging.

## Conclusions

To be an effective watershed, lake or stream leader, an individual must possess a variety of attributes that incorporate technical and social skills. Many leaders seek out continuing education and training programs to increase their capacity to lead water resource management efforts. This report offers a critical review of educational programs developed at four land-grant universities aimed at addressing the diverse educational needs of watershed and lake management leaders in Indiana, Ohio, Michigan, and Minnesota. Each included a common set of themes and topics that integrated both social and natural sciences. Additionally, networking and interactions either in-person, through online discussions, or through phone calls were regarded as highly valuable by participants and instructors in all four programs. Each of the programs included Extension educators in developing and presenting the programs. Extension appears to be well-suited to develop and run this type of program, with their expertise in adult education, knowledge of other experts in natural and social sciences, and connections from the local to state level.

Although most of our evaluations were not designed to compare delivery methods, we observed that no one method of delivery was overall more effective than another. Each delivery method offers different opportunities and impacts, as shown previously in adult learning literature and confirmed by reactions from program participants. An understanding of these differences combined with an understanding of the audience and desired education outcomes are the basis for an ideal program design. With online distance learning, courses can be self-paced, interactive, and archived for use by students at their convenience. No travel is involved, but participants must be computer literate. Face-to-face courses can include a diverse set of presenters, experiential outdoor learning opportunities, and interactive group exercises. Travel time can be a challenge for both participants and presenters. Whether the program is online or in-person, both modes provide participants with the capability to increase their knowledge for a broad set of topics, network with a diversity of people with varying expertise, connect with stakeholders and decision makers within their community, and sharpen their skills to become effective watershed, lake, and stream leaders.

These four programs exemplify the elements needed to develop a successful training program that fosters watershed, lake and stream leadership capacity: natural science knowledge, effective leadership and communication skills, networking, capacity building, effective tools and techniques, and community engagement. Building watershed leadership capacity parallels the features of good watershed management in that it 1) engages multiple stakeholders (e.g., through the use of advisory boards) in the development and delivery of the program, 2) integrates diverse biophysical and social science disciplines to address water resource issues, 3) recognizes and takes advantage of the diverse backgrounds and needs of participants, 4) gives learners plenty of individual (local) control over what to study and how to approach assignments to meet their needs, and 5) builds networks and networking capacity to support ongoing learning. These features characterize the strategies that watershed groups use to effectively manage water resources.

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# Informal Water Education and Public Outreach

## Issue Editor
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