Identifying Barriers Preventing Stormwater Pond Buffer Implementation in Coastal South Carolina

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Abstract. Buffer zones are ecotones between upland areas and adjacent water bodies. They often consist of plant communities that stabilize shorelines, act as barriers reducing transport of fertilizer and lawn debris into water bodies, uptake nutrients and heavy metals, and provide habitat for wildlife. Few regulations exist that require vegetated buffers around stormwater ponds, and their widespread implementation has not occurred around ponds in coastal South Carolina. This lack of regulation on buffer requirements has potentially reduced the effectiveness of stormwater ponds and highlights the need to identify barriers preventing residents from implementing vegetated buffers. To investigate the barriers preventing the installation or support for stormwater buffer zones in coastal communities, an electronic survey was sent by e-mail through the South Carolina Department of Natural Resources and Ashley Cooper Stormwater Education Consortium listservs. Of the 646 respondents, 382 met the study criteria and identified owning a property with a pond or living in a neighborhood with one. Respondents were asked questions to determine their knowledge and perceptions of vegetated buffers, as well as their level of communication with landscape professionals. Results from this research indicate that residents are aware of the benefits vegetated buffer zones provide and prefer ponds with buffer zones over ponds with no buffer zones. This study reveals the following potential barriers preventing stormwater pond vegetated buffer zones: 1) limited knowledge of the costs associated with installation of vegetated buffer zones, 2) inadequate communication between residents and landscape professionals who maintain ponds, 3) respondents perceived lack of control over pond-related decisions, and 4) social norms within neighborhoods such as grass sod standards and an aversion to non-manicured vegetation. These findings can be used by stormwater professionals to help increase adoption of stormwater pond best management practices (BMPs) and improve water quality protection in South Carolina.

INTRODUCTION

The reduction of natural land cover and transition to impervious surfaces, such as roads, parking lots, and buildings, impacts how water moves above and below ground during and following rainfall events. Urban and suburban settings typically have a much larger volume of stormwater runoff per given precipitation event than would occur in a similar landscape in rural, natural, or forested areas, often leading to a reduction in groundwater infiltration and evapotranspiration. From 2001 to 2016, developed land cover classes in South Carolina increased by the following percentages: open space (+5%), developed, medium intensity (+45%), developed, low intensity (+14%), and developed, high intensity (+39%) (Mikhailova et al. 2021). Increases in stormwater runoff can lead to flooding and altered conditions of nearby rivers, lakes, and estuaries through the transport of nutrients and pollutants into surface waters (Mallin et al. 2002; National Academies Press 2009). In the Southeastern United States, wet detention ponds, commonly referred to as stormwater ponds, are a widely adopted best management practice (BMP) to store stormwater runoff. Stormwater ponds are human-engineered structures that are designed to have permanent standing water and additional capacity to store water runoff from rain events. Stormwater ponds are designed to hold water for a period of 24–48 hours with the primary purpose to reduce first-flush flooding and prevent nonpoint source pollution (NPS) from entering
receiving waterways. When designed and functioning properly, this stormwater control measure treats runoff by allowing suspended solids including nutrients, pollutants, and sediment to settle and be retained at the bottom of the pond (Mallin et al. 2002).

Although stormwater ponds have been established as a BMP to provide treatment of stormwater runoff, they are often only designed to meet minimum requirements and, after construction, can be mismanaged by pond owners (Monaghan et al. 2016). Mismanaged ponds can lead to poor water quality caused by blooms of toxic algal species, microbial contamination from fecal matter, low water circulation, and chemicals from NPS (DeLorenzo et al. 2012). A recommended practice to improve water quality in stormwater ponds is the implementation of vegetated buffer zones, the area in which plants are located along the littoral and bank slope zone of a pond, stream, or shoreline (Figure 1). Buffer zone plants stabilize shorelines, uptake nutrients, and reduce the flow velocity of runoff, allowing some pollutants to settle before reaching the pond, increasing the potential for improved water quality (US EPA 2021).

Many pond banks and shorelines are designed and maintained with only a monoculture of turf grass and are mowed to the water’s edge. The shallow root system of turf grass does little to stabilize banks and frequent mowing places stress on pond edges and can lead to shoreline erosion. Mowing along pond edges also adds grass clippings, a source of nutrients, to the pond (Cotti-Rausch et al. 2019). Ponds without buffer zones reduce their potential effectiveness, highlighting the need to identify what barriers prevent homeowners from successfully implementing this stormwater pond BMPs. Stormwater pond landscape-related BMPs often have low implementation rates (Monaghan et al. 2016; Schroer et al. 2018). However, the current extent of buffer implementation has not been quantified. Previous research has shown that norms and perceived expectations of peers can influence individual behaviors relating to environmental issues (Robbins et al. 2001). Social norms, or normative beliefs, are the way people think certain behaviors will be viewed by the individuals or groups around them. Social norms have been suggested as a potential barrier preventing vegetated buffer zone implementation on stormwater ponds (Sanagorski and Monaghan 2014).

**STORMWATER PONDS**

**OWNERSHIP AND GOVERNANCE**

Stormwater ponds are a widespread BMP used to store and provide treatment of stormwater runoff. Once construction of the site is completed, post-construction responsibility passes to the property owner, who is often the Homeowners Association (HOA). Individual property owners or HOAs often lack the knowledge or resources to properly manage stormwater ponds, leading to potential water quality impairments. Ponds located in residential communities are often private ponds and are not maintained by local, state, or federal agencies. In coastal South Carolina, the surface waters of many stormwater ponds have been documented to exhibit poor water quality, including harmful algal blooms, fish kills, and high concentrations of fecal coliform bacteria, as well as low dissolved oxygen concentrations (Drescher et al. 2007).

![Vegetated pond bank in a community near Myrtle Beach, SC.](photo_credit: Katie Ann Callahan, Clemson Center for Watershed Excellence.)
**BENEFITS OF POND VEGETATED BUFFERS**
Diverse vegetation around the perimeter of a pond reduces erosion by stabilizing the shoreline, enhances the removal of dissolved nutrients in urban stormwater discharges, and provides habitat for aquatic and wetland wildlife (Clar et al. 2004). Aquatic, littoral, and shoreline plants also block sunlight, which lowers water temperature and decreases the growth of nuisance algae (Monaghan et al. 2016). The design and proper selection of native aquatic and littoral vegetation found in buffer zones is vital to the overall effectiveness of stormwater ponds. A major design component of stormwater ponds is their ability to trap and retain sediments, particles, and dissolved nutrients from runoff. Ponds without plant buffer zones tend to experience greater inputs of nutrient-rich grass clippings that can degrade water quality (Ott et al. 2015). Increased inputs of sediment can reduce the original volume capacity of the pond reducing its effectiveness. South Carolina state regulations require ponds to be dredged when sediment accumulation reduces a pond’s storage volume by 25% or more (SCDHEC 2005). The costs associated with dredging can place a significant financial strain on HOAs and many lack the funds necessary to conduct the required pond maintenance and dredging (Cotti-Rausch et al. 2019). The root systems of plants located within a vegetated buffer provide shoreline erosion control, preventing large inputs of sediments from entering ponds, and reducing or limiting costs associated with shoreline restoration and dredging.

**POND LANDSCAPE MANAGEMENT AND MAINTENANCE**
HOA covenants and community norms play a large role in household lawn behaviors. HOAs provide written rules backed by legal means of enforcement and often establish unwritten expectations forcing individual homeowners into compliance with landscaping guidelines. By enforcing aesthetic standards, such as green and weed-free lawns, HOAs encourage higher usage of chemicals to meet those standards (Fraser et al. 2013). Although the benefits of vegetated buffer zones have been well documented, landscape crews and homeowners frequently mow and reduce vegetation directly to the edge of the water, decreasing the efficiency of the retention pond by removing vegetation that slow and trap sediments, pollutants, and nutrients before entering the pond (Schroer et al. 2018). A study of a master planned community in Florida found that even though homeowners understood the role stormwater ponds played in water quality, most were unwilling to adopt shoreline plantings (Monaghan et al. 2016). Respondents of the survey expressed that shoreline plants may lower their property value, reduce visibility to the pond or lake, and were uncertain how their neighbors would accept and perceive changes to the shoreline planting around the pond (Persaud et al. 2016). Another study found water clarity was considered a main factor influencing perception of ponds while diverse plantings at the pond edge were generally disliked and thought to reduce property value (Monaghan et al. 2016).

**STORMWATER OUTREACH**
The importance of vegetated buffers surrounding stormwater ponds has been emphasized by stormwater outreach professionals; however, widespread adoption of vegetated buffer zones in the ACE Basin National Estuarine Research Reserve (NERR) service area has not been documented. The ACE Basin NERR is a state and federal partnership between the National Oceanic and Atmospheric Administration’s Office for Coastal Management and the South Carolina Department of Natural Resources (SCDNR) Marine Resources Division. A goal of the ACE Basin NERR is to reduce negative pressures on coastal ecosystems and Reserve watersheds. To achieve this goal, the ACE Basin NERR has collaborated with other state agencies that have established programs aimed at reducing the negative impacts of stormwater runoff in the coastal region of South Carolina. The Carolina Clear program administered through Clemson Extension provides training, workshops, and resources to educate and inform the citizens of South Carolina of the issues related to stormwater runoff. In 2014, the South Carolina Sea Grant Consortium (SCSGC) also began a collaborative effort to increase research and outreach programs to address challenges relating to stormwater ponds in coastal South Carolina (Cotti-Rausch et al. 2019).

**PROJECT GOALS**
This project attempted to achieve the following goals:

1. Approximate stormwater pond vegetated buffer zone implementation in coastal South Carolina.
2. Identify knowledge gaps and perception of vegetated buffer zones in coastal South Carolina.
3. Compile potential barriers to implementing stormwater pond best management practices.
4. Determine if certain communication practices influence implementation of landscaping-related stormwater pond BMPs in residential communities.

**STUDY AREA**
Responses for this survey were collected primarily from the eight coastal counties of South Carolina (Figure 2), but stormwater ponds are located throughout the state, so responses from the whole of South Carolina were collected and used for analysis.
NEEDS ASSESSMENT
The Healthy Pond Series (HPS) was established to help meet the goal of education and outreach for Clemson Extension's Carolina Clear program and partner agencies. The HPS is a community-based discussion series for pond owners to learn and share stormwater pond management solutions. Additionally, the HPS program provides an opportunity for HOA representatives, property managers, pond owners, and pond managers to increase their knowledge of pond BMPs. The series is organized and administered in collaboration with SCDNR, Clemson Extension, and the SCSGC. The Charleston and Beaufort area HPS has conducted 23 events with 999 registrants since its inception in 2017. Of the 23 different events, vegetated buffers have been the primary topic three times, and many events have highlighted various benefits provided by vegetated buffers. Evaluations for the HPS have been collected after each event and compiled by the ACE Basin NERR Coastal Training Program. As part of this project, an initial analysis of the evaluation data was conducted to identify the topics that were the most useful to participants and additional training topics of interest. Results from the evaluation survey data indicated that participants of HPS events have requested more information and training about vegetated buffer zones.

SURVEY DESIGN
An electronic survey was used to gain insight into pond management behaviors of residents in coastal South Carolina. Questions were designed to gain a better understanding of the frequency of vegetated buffer zone implementation, highlight knowledge gaps about vegetated buffer zones, determine what barriers prevent buffer zone implementation, and document perceptions of various vegetated buffer zones. A 67-question survey was designed based on a survey conducted by Monaghan et al. (2016) of residents in a master-planned community in Florida. This research project used a mix of Likert scale, yes/no responses, open-ended, and multiple-choice questions. To ensure respondents were only asked questions that were relevant to their situation, logic functions were incorporated into the survey design. For example, if a respondent selected “no” to the question, “Do you live in a neighborhood with a Homeowners Association (HOA) or community association?” they would not be asked any further questions relating to HOAs. If respondents selected “no” to the question, “Do you live in a neighborhood or development with a pond?” or “no” to the question “Is there a pond on your property or adjacent to your property?” the survey terminated, and they were not asked any further questions. Environmental Systems Research Institute (Esri) Survey123™ software was chosen as the survey platform for its ability to record responses spatially. During a series of questions to gain background information, respondents were asked, “Please use the map to identify the pond location in your neighborhood.” If a respondent selected their pond on the map, latitude and longitude coordinates were generated which created an individual geopoint for each survey participant. The Survey 123™ application allows an end user to access survey results by using an interactive interface, which provides access to any geopoint and corresponding responses.

A series of pictures representing different pond shorelines were used to allow participants to choose which pond looks most like the pond in their neighborhood and what pond they would prefer to have in their neighborhood. Another series of pictures was used to allow respondents to choose what type of buffer they would prefer to have on their pond and what type of buffer they believe their neighbors would prefer to have on their pond. The series of questions asking respondents their attitudes towards different vegetated buffer zones was adopted from Monaghan et al. (2016). These questions were included to determine neighborhood norms that exist in South Carolina that influence the behaviors of residents and prevent the implementation of buffer zones.

A test survey was sent to various subject matter experts in February 2022. Edits were made to the survey based on comments provided and the research proposal was sent to the College of Charleston's Institution Review Board (IRB). The project was verified as exempt according to 45CFR46.101(b) (2): (2) Tests, Surveys, Interviews in May of 2022 (IRB Protocol #2022-02-007).

SURVEY RECRUITMENT
A recruitment email containing a link to an electronic survey was sent to 18,187 people on June 20, 2022. The email was sent using SCDNR's GovDelivery account and included contacts from the Coastal Exploration Series and Coastal Training Program. Recruitment emails were sent to an additional 130 people through the Ashley Cooper Stormwater Education Consortium listserv. The recruitment email encouraged recipients to share the survey link with “anyone else who may be interested in providing insight to help improve water quality in coastal South Carolina.” A reminder email was sent to the same contact lists on July 7th, 2022. The survey link was live from June 20th to July 14th, 2022.

RESULTS
DEMOGRAPHICS
Of the 646 survey responses, 382 met the study criteria and identified owning a property with a pond or living in a neighborhood with a pond. Most respondents’ ponds were 10 years or older (70%) and 48% were 20 years or older. Most respondents have lived in South Carolina for 10 or more years (60%) and 64% have a pond on their property or adjacent to their property. Beaufort County had the highest
number of respondents, with 36% of respondents identifying they lived on a pond or in a neighborhood with a pond, followed by Charleston County with 22% of responses. Most respondents (76%) live in a community with an HOA, but only 11% of respondents indicated they are HOA board members.

**POND MANAGEMENT DECISIONS**

When asked to rate their level of agreement or disagreement with the statement “I have control over the decisions made concerning the management of the pond(s) on my property or pond(s) in my neighborhood,” 63% disagreed or strongly disagreed. Forty-eight percent of respondents indicated that a HOA board is responsible for pond landscape management decisions and 25% were unsure who was responsible. Although 70% of respondents selected that they have a designated member or committee responsible for landscaping related decisions, only 42% stated that their HOA has a designated member or committee responsible for pond specific decisions. Out of the 292 residents in HOA communities, 63% selected that their HOA designates a portion of the budget for pond-related expenses.

HOAs that have a designated member or committee responsible for pond-related decisions have a higher percentage of buffer zone implementation compared to neighborhoods with no designated member or committee responsible for pond-related decisions. Forty-two percent of respondents who live in a community with a HOA have a designated member or committee responsible for pond-related decisions. Of these respondents, 35% have a buffer zone on the pond in their neighborhood compared to 25% of respondents who do not have a committee for pond-related decisions. Most respondents who live in a community with an HOA indicated that their HOA designates a portion of their budget for pond-related expenses (63%). HOAs with a designated portion of their budget for pond-related expenses had a slightly higher percentage of ponds with vegetative buffers (31%) compared to HOAs with no budget for pond-related expenses (30%).

**COMMUNICATION**

Communication between respondents and the landscape company that maintains the area surrounding their pond is rare. Only 14% of respondents that use a landscape company to maintain the area around their pond or the pond in their neighborhood selected they communicate with the landscape professional. Of the respondents that communicate with their landscape professional, 6% are on the HOA board. Few respondents indicated there was a language barrier between them and their landscape company (11%) and only one respondent indicated that a landscape company has removed vegetation along the shoreline of their pond against their direction. Although very few respondents indicated that they communicate with their landscape company that maintains the area surrounding the pond(s) on their property or the pond(s) located in their neighborhood, 44% of respondents that communicate with their landscape company have a vegetative buffer zone while only 22% of respondents that do not communicate with their landscape company have a vegetative buffer zone on their pond.

**EXISTING BUFFERS AND INSTALLATION**

Results show that 32% of respondents have a vegetated buffer zone on their pond or on the pond in their neighborhood, a higher percentage than expected based on observations from past outreach events. Twenty-one percent of respondents selected that they have attempted, or their neighborhood has attempted, to install a vegetated buffer. Respondents located in Beaufort County had the most buffers (43) followed by Charleston County (30) (Figure 2).

**AWARENESS**

Most survey respondents are aware of the basic function of stormwater ponds. Seventy-seven percent of survey respondents selected that flood control was a very important or extremely important feature of their pond. Seventy-nine percent of respondents selected that water quality improvement was a very important or extremely important function of their pond. Most survey respondents were aware that ponds with shoreline plants improve the water quality of the pond (85%) and that ponds with plants on the shoreline uptake nutrients and pollutants (76%) (Figure 3). Sixty-seven percent of respondents agree or strongly agree that shoreline plants can reduce long term maintenance costs (Figure 3). Although respondents were generally aware of the benefits and function of buffer zones, 25% of respondents identified members of their HOA board are unaware of the benefits of buffer zones. Most respondents (57%) selected neither agree nor disagree with the statement “shoreline plants are affordable and easy to install” (Figure 3). This question elicited the most neutral responses out of all the Likert scale questions in the survey, indicating respondents are unaware of the costs and process associated with buffer zone installation.

**TRAINING**

Of the 382 respondents that met the survey criteria, 26% attended or completed a pond-related training provided by Clemson Extension, ACE Basin NERR, SCSGC, or SCDNR (Table 1). Those who attended a pond-related training had a greater understanding of the function of stormwater ponds, what a vegetated buffer is, and the benefits of vegetated buffers (Table 1). Nearly all respondents who attended a pond-related training indicated that they are aware of the benefits of a vegetative buffer zone (93%). In comparison, of the 275 respondents who have not attended a training, 67% are aware...
of the benefits provided by a buffer zone. Respondents who attended a training also identified that they have more control over the decisions made concerning the management of the ponds. Twenty-three percent of respondents who attended a training selected they agree or strongly agree that they have control over pond decisions compared to only 14% who have not attended a training. Individuals who attended a training indicated having a buffer surrounding their pond at a slightly higher frequency (M=2.8, SD=1.34) than those who did not attend a training (M=2.69, SD=1.2) (Table 1). In addition, 29% of respondents who have attended a training have attempted, or their neighborhood has attempted, to install a vegetated buffer zone, compared to only 18% of respondents who have not attended a training. Of the respondents who have attempted to install a buffer, 79% of respondents that attended a training were successful with their installation compared to 76% for those who did not attend training.

PREFERENCE AND PERCEPTION
Images of eight different ponds were used to allow respondents to select which pond best represents the pond shoreline in their neighborhood as well as what pond shoreline they would prefer to have. Pond G, with no vegetated buffer and exhibiting erosion along the shoreline, was most frequently selected as the pond that best represented the shoreline in their neighborhood, with 25% of responses (Figure 4). Pond E, a pond with a vegetated buffer of diverse vegetation and flowering plants, was the most preferred pond, selected by 40% of respondents. Ponds with some form of vegetated buffer zones, (A, C, D, and E) were selected as their preferred pond by 69% of respondents (Figure 4). Few respondents (6%) agree or strongly agree that "shoreline plants decrease property values," 27% stated that shoreline plants are harder to maintain than grass, and 21% of respondents stated that "shoreline plants grow out of control and do not look good" (Figure 3).

WILLINGNESS TO ACCEPT OR REQUEST
Pictures of three different vegetated buffer zones were used to determine the level of acceptance for a "low mow" area with taller turfgrass, a pond with a planted vegetated buffer, and a pond with a "no mow" meadow (Figure 5). Respondents were asked "How likely are you to accept or request the installation of shoreline plants around your pond such as those shown in the picture below?" and "How likely are your neighbors to accept or request the installation of shoreline plants around
their pond such as those shown in the picture below?" Most respondents (67%) indicated that they would be likely or very likely to request the installation of a vegetated buffer shown in the photo of pond E. In contrast, only 30% of respondents thought their neighbors would be likely or very likely to request or accept a buffer shown in the photo of pond E. The least preferred pond buffer was the low mow, with only 43% of respondents selecting that they would be likely or very likely to accept or request that form of buffer. Results from this series of questions show that respondents were more likely to accept or request all three types of vegetated buffers than they believed their neighbors would.

Table 1. Mean ratings of agreement to statements regarding pond function and perception of shoreline plants. Columns are comparing respondents who attended training (n=100) and those who have not attended training (n=275). Agreement ranged from strongly disagree (1) to strongly agree (5).

<table>
<thead>
<tr>
<th>Statement</th>
<th>No Training (n=275)</th>
<th>Training (n=100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ponds control flooding on my property or in my neighborhood.</td>
<td>4.00</td>
<td>4.11</td>
</tr>
<tr>
<td>Ponds improve water quality in areas not directly located within my property or neighborhood (cracks, streams, rivers, ocean).</td>
<td>3.97</td>
<td>4.27</td>
</tr>
<tr>
<td>Ponds provide an amenity that increases my property value.</td>
<td>3.55</td>
<td>3.61</td>
</tr>
<tr>
<td>Ponds with plants on the shoreline uptake nutrients and pollutants.</td>
<td>3.94</td>
<td>4.16</td>
</tr>
<tr>
<td>Ponds with plants on the shoreline improve the water quality of the pond.</td>
<td>4.17</td>
<td>4.32</td>
</tr>
<tr>
<td>Shoreline plants are affordable and easy to install.</td>
<td>3.26</td>
<td>3.35</td>
</tr>
<tr>
<td>Shoreline plants can reduce long-term maintenance costs associated with pond management.</td>
<td>3.76</td>
<td>3.94</td>
</tr>
<tr>
<td>I was aware of the benefits of a vegetative buffer zone surrounding the shoreline of a pond prior to taking this survey.</td>
<td>3.61</td>
<td>4.45</td>
</tr>
<tr>
<td>The pond(s) on my property or in my neighborhood have a vegetative buffer zone (shoreline and/or aquatic plants).</td>
<td>2.69</td>
<td>2.80</td>
</tr>
<tr>
<td>Shoreline plants grow out of control and do not look good.</td>
<td>2.57</td>
<td>2.42</td>
</tr>
<tr>
<td>Shoreline plants are harder to maintain than grass.</td>
<td>2.70</td>
<td>2.52</td>
</tr>
<tr>
<td>Shoreline plants decrease property values.</td>
<td>2.19</td>
<td>2.13</td>
</tr>
</tbody>
</table>

Figure 3. Frequency distribution of responses to the question “Please rate your agreement or disagreement with the following statements about vegetated buffer zones” (n=382).
Figure 4. Frequency distribution comparing the responses to the questions “Please select the picture that best resembles the shoreline of the pond(s) on your property or pond(s) located in your neighborhood” and “Please select the picture of the pond you would prefer to have in your neighborhood or on your property” (n=382). A, No mow (Photo Credit: Solitude Lake Management). B, Bulkhead (Photo Credit: Residential Marine Walls). C, Low mow (Photo Credit: Texas A&M AgriLife Extension). D, No mow 2 (Photo Credit: Guinn Wallover). E, Planted Buffer (Photo Credit: Katie Ann Callahan). F, Turfgrass (Photo Credit: Riverside at Carolina Park). G, Eroded Shoreline (Photo Credit: Guinn Wallover). H, Turfgrass 2 (Photo Credit: Lapin Services).
DISCUSSION

The respondents from this survey were targeted using SCDNR and stormwater consortium email contact lists. Responses collected may not accurately represent the entire population of South Carolina. The survey sample is more likely to consist of residents who already possess a greater understanding and interest in water quality issues. Additionally, the survey revealed that even among respondents who haven’t attended a pond-related training, there was a high level of awareness about the function and benefits of buffer zones. This observation further emphasizes the skewed nature of the sample population, suggesting that even those who haven't received formal training in pond-related matters already possess a considerable knowledge about buffer zones.

AWARENESS AND PERCEPTION

The research revealed that even though respondents prefer ponds with vegetated buffers and are aware of their benefits, few residents have implemented vegetated buffer zones on their ponds. This finding highlights the role social norms play in influencing landscaping behaviors and pond management practices. Previous research highlights that landscape management norms are often an expression of affluence and group identity (Cook et al. 2012). Although residents are aware of the benefits and prefer a pond with a vegetated buffer zone, they likely do not attempt to install a buffer zone to conform to the established social norm of turf grass landscaping. If more residents were aware a large proportion of their neighbors prefer and would accept the installation of buffer zones, they may be more likely to request the implementation of buffer zones around the ponds in their neighborhood. Cook et al. (2012) described how socioeconomic advantage, education, and lifestyle factors positively influence vegetation diversity and cover at a neighborhood scale. Further research is needed to identify how socioeconomic factors influence buffer zone perception and willingness to adopt.

Respondents who have attended a pond-related training had a greater understanding of the benefits and function of vegetated buffer zones compared to respondents who had not attended a training. Survey results also identified that residents prefer ponds with vegetated buffer zones over ponds with no buffer zone. However, most residents were either unsure or did not believe that their neighbors would accept or request vegetated buffer zones on the pond(s) in their neighborhood. This finding is consistent with previous social science research on normative behaviors influencing landscaping practices. Formal and informal institutions have been shown to prevent individuals from acting on their personal preferences and explains why landscaping choices often deviate from residents’ attitudes (Cook et al. 2012).
A previous survey of one master planned community in Florida by Monaghan et al. in 2016 revealed that 37% (n=429) of residents who lived on a pond were likely or very likely to request the installation of shoreline plants. Only ~15% of respondents thought their neighbors would likely request or accept the installation of shoreline plants. In comparison, this study revealed 67% (n=382) of respondents who live on a pond or have a pond in their neighborhood were likely or very likely to request the installation of shoreline plants. This study also revealed 30% of respondents thought their neighbors would likely accept or request the installation of shoreline plants. The difference in these findings may be due in part to the target populations of each study. The 2016 study only targeted one large master planned community and used snowball sampling to encourage respondents to share the survey only with residents in their neighborhood. On the other hand, respondents from this study were located throughout South Carolina and were contacted using SCDNR and stormwater consortium contact lists. Respondents of this survey were likely more aware of water quality related issues than respondents to the 2016 Monaghan et al. study and may be a factor that contributed to the differences in likelihood to accept or request buffer zones.

**RECOMMENDATIONS**

1. Use Social Norms to Influence Behaviors
   a. Promote Vegetated Buffers with Visual Examples: Outreach and education efforts should continue to promote vegetated buffers by using the picture of Pond E as an example of a vegetated buffer, or images with similar shorelines.
   b. Build Community Support: Marketing and communication should focus on shifting social norms to increase adoption of vegetated buffers surrounding stormwater ponds. Sanagorski and Monaghan (2014) highlight the need to use social norms to increase behavior change for sustainable landscaping. They suggest choosing a behavior that is perceived as positive and making the norm noticeable to the target audience. Stormwater outreach and marketing should emphasize the positive perception residents have towards stormwater pond buffer zones. Outreach professionals can provide information to a particular community, specifically HOA board members, in the form of a flyer, presentation, or demonstration, explaining the importance of vegetated buffer zones and highlighting how research has indicated that residents often prefer ponds with buffer zones.

2. Improve Outreach and Training
   a. Provide Cost and Installation Estimates: Respondents were undecided about the costs and process associated with the installation of vegetated buffers, pointing to an opportunity to increase or improve outreach and education efforts.
   b. Target HOA Board Members and Presidents: Survey results indicated that most respondents did not feel like they had control over pond management decisions. This finding also supports themes identified in responses from previous stormwater pond outreach evaluation data. Participants of stormwater pond outreach events have stated that they would like training to learn how to inform and influence other members of their HOA and HOA board members to adopt stormwater BMPs. This finding also highlights the need to identify residents who can enact change and make the decisions necessary to implement BMPs.
   c. Encourage Pond Committees and Budget Allocation for Ponds: Survey results identified that the primary decision makers are HOA board members, indicating that training and outreach efforts should directly identify HOA board members for outreach and educational programs. Survey results also indicate that HOAs with a designated member or committee responsible for pond-related decisions have a higher percentage of buffer zone implementation compared to neighborhoods with no member or committee responsible for pond-related decisions. Stormwater education programs should continue to encourage HOAs to establish a specific committee or appoint a member responsible for pond-related decisions to encourage the adoption of BMPs. Results from this study indicate that respondents who live in a neighborhood with a HOA and have a designated portion of their budget for pond-related expense have a slightly higher percentage of vegetated buffer implementation compared to HOAs with no designated budget for pond-related expense. This highlights the importance of allocating a portion of the overall HOA budget for pond-related expenses. Outreach programs should continue to educate HOA board members of the various pond-related expenses and emphasize the potential cost saving benefits associated with vegetated buffer zones and other BMPs.
3. Increase Landscaping Communication

a. Explore Landscape Professional Engagement: Although survey results highlight that very few respondents communicate with the landscape professional who maintains the area surrounding the pond in their neighborhood, this study has identified individuals for participation in future research efforts. Further research should be conducted to determine if increased communication between landscape professionals and HOAs can influence buffer zone implementation. In addition, conducting surveys or interviews with landscape professionals to determine their training needs will provide beneficial insights.

b. Emphasize Communication between HOAs and Landscape Professionals: Training landscape professionals to leave a buffer zone to grow would be a no cost or low-cost way of implementing a buffer zone. Although low mow and no mow buffer zones were the least preferred buffer based on responses from this study, these forms of buffer zones can provide temporary benefits until the HOA is able to install a more robust vegetated buffer zone. Outreach professionals should address the lack of awareness about buffer cost and maintenance highlighted in this study by educating residents that low-mow or no mow buffers require minimal maintenance and can be a cost-effective shoreline management option. Although few respondents stated that they communicate with their landscape company, those who did so had a higher percentage of buffer zone implementation than those who did not. Outreach and education should emphasize the importance of communication between HOAs and landscape companies. More research is needed for a better understanding of how communication between individuals and landscape professionals may influence the adoption of BMPs in South Carolina.

4. Update Stormwater Standards

a. Include Vegetated Buffer Zones in Regulations: Stormwater ponds are a prevalent feature in neighborhoods and developments throughout South Carolina and are constructed to store and treat runoff during and after a rainfall event. The reliance on HOAs for the management of stormwater ponds can often lead to water quality impairments within ponds and receiving waterbodies. Vegetated buffer zones are a BMP that can help to stabilize shorelines, prevent the transport of nutrients, pollutants, and sediments into ponds, and can help prevent water quality impairments. However, current regulations at the state level do not require vegetated buffer zones around stormwater ponds. Outreach and education programs have focused on the function and importance of vegetated buffers, yet widespread implementation has not occurred in coastal South Carolina. This study identified that respondents were aware of the function and benefits of stormwater ponds, and prefer ponds with buffer zones, yet implementation of buffer zones is low. This study also highlights that residents who have attended a pond-related training have increased knowledge of the benefits of buffer zones, but only have slightly higher rates of buffer zone implementation compared to those who have not attended a training. While stormwater professionals should continue prioritizing outreach programs, it appears that relying solely on education does not significantly impact the implementation of vegetated buffer zones in coastal South Carolina. Updating stormwater permitting requirements to include vegetated buffer zones would shift the responsibility from HOAs or individual property owners to the developers. Relying solely on HOAs or individual property owners to implement vegetated buffer zones has led to barriers in adoption. The results from this study can be used to inform regulators at the municipal, county, and state level that buffer zones have public support and should be incorporated into new stormwater pond designs.

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