Research Reports

Optimizing Shoreline Planting Design for Urban Residential Stormwater Systems: Aligning Visual Quality and Environmental Functions

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ADDITIONAL INDEX WORDS. pond, buffer, wildlife, aesthetics, vegetation, landscape

SUMMARY. Stormwater ponds are widely used in urban developments to control and clean stormwater and add aesthetic appeal to the landscape. This dual function of residential stormwater systems can create conditions at odds for the optimal performance of either function. This investigation sought to discover connections between aesthetics, plants, design, maintenance, and municipal codes as a means to improve water quality and stormwater pond appearance. To establish the connections between visual quality and environmental function, we conducted five focus groups, four interviews with landscape professionals, and reviewed regulatory codes for 46 municipalities. We concluded that homeowner preferences and the social influence of neighbors were closely linked to design, codes, and management issues. Insights gained include the shared social value of wildlife viewing and aesthetic preferences for diverse, but maintained shoreline planting.

Urbanization removes natural vegetation and increases impervious areas, which threatens water quality and the health of downstream waters (Barbosa et al., 2012; National Research Council, 2008).

This work was supported by the National Natural Science Foundation of China (No. 31600576), the Fundamental Research Funds for the Central Universities (No. 2572015BX06), and Scientific Research Foundation of Northeast Forestry University (No. QG2015-03). The focus group study was funded by the Southwest Florida Water Management District.

We would like to thank Emily Ott and Amanda Concha-Holmes (University of Florida) for their assistance with the focus groups.

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doi: 10.21273/HORTTECH03580-16

Many communities have adopted a variety of stormwater control measures (SCMs), which are structural (such as stormwater ponds) or nonstructural practices (such as site design and landscape management) that reduce the impact of stormwater runoff on water quality of receiving waters (National Research Council, 2008). Commonly used techniques to manage urban stormwater include sustainable urban drainage systems (SUDSs), low impact development (LID), and best management practices (BMPs). SUDS focus on replicating natural systems to manage urban stormwater sustainably. LID simulates natural hydrology through appropriate site layout and integrated vegetated methods (as opposed to end-of-catchment measures), and BMPs denote a type of practice, such as rain gardens that reduce pollution of water bodies (Autixier et al., 2014; Fletcher

et al., 2014). All of these approaches provide ecosystem services (the benefits we receive from nature), including runoff regulation and water quality protection by a variety of stormwater facilities, including bio-retention basins, rain gardens, and green streets (Armson et al., 2013; Lucke and Nichols, 2015; Yang et al., 2013). Studies on the social and broader environmental aspect of urban stormwater management techniques show the potential for improved aesthetics and biodiversity (Benvenuti, 2014; Church, 2015; Dunnet, 2010; Kazemi et al., 2011). Other studies have shown aesthetics is one of the key considerations for adoption of these measures in communities (Baptiste et al., 2015).

The dual function of the stormwater systems, to control and clean water and provide aesthetic value can be at odds due to the design, the surrounding landscaping, and the maintenance practices of homeowners (Baptiste et al., 2015; Guevara 2008). Stormwater ponds mimic the natural hydrological system and provide benefits such as flood control, increased property value, wildlife habitat, recreation, and aesthetic amenities (Bastien et al., 2012; Moore and Hunt, 2012; Tixier et al., 2011; Walker et al., 2013). Many urban ponds also have significant water quality and aesthetic issues that result from ineffective design and maintenance treatments. For example, design flaws such as lack of pretreatment areas and incorrect pond depth decrease environmental health (Walker et al., 2010). Pond landscape design and management is occasionally included in landscape management policies and landscape ordinances laws that regulate landscape design, installation, and maintenance (Fraser et al., 2013; Sisser et al., 2016). As ponds age, they can develop structural problems and may not meet current standards for stormwater treatment (Harper and Baker, 2007). Although stormwater ponds remove nonpoint source pollutants from the water course, the pond itself can also become polluted, leading to eutrophication and algae growth (Lewitus et al., 2008).

Serrano and DeLorenzo (2008) summarized five stormwater pond management techniques to improve water quality and control algae growth in residential neighborhoods, one of which was installing a vegetative buffer. Using upland plantings around pond

shorelines for visual quality can reduce fertilized areas and allow nutrient uptake from yards (Keddy, 2000; North-eastern Illinois Planning Commission, 1996). Using shoreline plants may improve the visual quality of the water by controlling algae blooms and adding “interest” to the shoreline (Castelle et al., 1992). Some studies have shown plants filter nutrients from stormwater runoff and are needed for protecting water quality (National Research Council, 2008; Srivastava et al., 2008; Zheng et al., 2006). However, nutrient removal is dependent on the density and coverage of plants (Collins et al., 2010; Mallin et al., 2002). Other studies caution that the nutrient removal in stormwater systems is dependent on many variables and there are limitations to a plant’s ability to uptake nutrients, especially phosphorus (Kadlec and Knight, 2008; Vincent and Kirkwood, 2014; Vymazal, 2007).

In our study, homeowner’s dissatisfaction with the loss of visual quality in neighborhood stormwater ponds, mainly from algae blooms, provided the opportunity to learn about homeowner perceptions about the environmental health of the ponds and their preferences for shoreline plants. The goal of the research was to discover any alignments of visual quality and environmental function to strengthen the proposal for using planted shorelines around neighborhood ponds. To improve aesthetics and water quality, our investigation focused on perceptions, preferences, and barriers to installing upland and aquatic plantings in stormwater ponds.

Methods

A mixed methods approach was used to collect data to understand how homeowners and landscape managers perceived pond issues and to clarify the role of municipal codes (Fig. 1). The methods included five focus groups with homeowners to explore their preference for neighborhood pond landscapes and plant species; four personal interviews with landscape designers and managers to understand the design and management issues they commonly encounter with stormwater ponds and a review of municipal codes for 46 municipalities to learn how regulations affect stormwater pond design.

The three methods allowed a triangulation of qualitative data from different sources and a way to compare the effects each one had on the other categories (codes, homeowners, and managers). The use of these qualitative approaches is appropriate for this type of investigation because of the complexity of the issues (individual knowledge, behaviors, social norms, environmental, and economic influences) and because they provide context and an insider’s point of view (Guba and Lincoln, 1994).

FOCUS GROUP STUDY. The research team conducted five focus groups in 2010 and 2011 in two residential communities in southwest Florida. Located on Florida’s Gulf Coast, both developments had numerous stormwater ponds with minimal shoreline plantings (Fig. 2). Focus group recruitment was based on snowball sampling, meaning residents recommended other residents

they thought would be interested in the issue of neighborhood ponds. Because of this, the focus groups were largely homogenous with most participants sharing some experience with the issues surrounding stormwater ponds. Participants could comment on aesthetic preferences and management problems such as algae blooms and overgrowth and they knew how their neighbors felt. This confidence in the social norms of the neighbors was a sentiment often repeated in the focus groups. This shared experience creates a type of “segment” of the population of the communities involved and allows focus on their expertise with the topic (Morgan, 1996). A total of 38 residents, including 23 men and 15 women, participated. The majority lived directly on a stormwater pond or had a view of a pond. They had an average of 9 years living in the community. Although five focus group

Fig. 1. Framework for investigation. The methods included focus groups with homeowners, personal interviews with landscape designers and managers, and a review of municipal codes. These methods allowed a triangulation of data from different sources.

interviews is a minimum amount (Morgan, 1996) for a specific topic such as opinions about stormwater ponds, each of the interviews achieved a degree of information saturation (Morgan, 1996). Each 2-h focus group was guided by a moderator with an interview script that included questions about community landscape satisfaction, household landscape management, fertilization, use of contractors, knowledge regarding nutrients, and water quality. A variety of questions were developed for the focus group meetings and longer interviews (Table 1). The

interviews were digitally recorded and transcribed. The text was coded, sorted, and arranged into categories using Nvivo 9 software (QSR International, Melbourne, Australia). Coding was done by multiple researchers using a constant comparative method of organizing segments of text into related categories—some categories were predetermined by the focus group script and others emerged from the participant responses. Categories became themes after segments of text were reviewed, compared, and found to have key words and phrases with an obvious

relationship. Although coding was focused largely on the categories created by the questions and the need to motivate behavior change, the process also allowed for unexpected insights and the formation of new theories about homeowner knowledge and attitudes (Corbin and Strauss, 2008).

LANDSCAPE PROFESSIONAL INTERVIEWS. In-depth personal interviews are commonly used in the field of landscape research (Carlet, 2015; Matthews et al., 2015). It is a powerful approach to explore the experience of a person on specific topics; among all methods of inquiry it is

Fig. 2. Typical pond shoreline in study area. These stormwater ponds have minimal shoreline plantings with turf down to the water in the backyards.

Table 1. Scripted questions for the focus groups and interviews of professionals addressed landscape preferences, stormwater pond knowledge, landscape maintenance, and communication efforts.

Studies	Script questions
Focus group	<ol style="list-style-type: none"> 1. Likes/dislikes about their neighborhood 2. Perceptions and preference toward neighborhood landscape 3. Experiences with landscape practices including fertilizer application 4. Knowledge of nutrient connection to pond problems 5. What participants liked about the pond 6. Observations of the characteristics of the pond 7. Understanding of the stormwater retention pond function 8. Communication among/with other residents within neighborhood association and with landscapers
Professional interview	<ol style="list-style-type: none"> 1. What problems are encountered with the shoreline plantings 2. What solutions to the problems 3. Efforts to balance between aesthetics and ecology in the design of the plantings 4. Plant material selection considerations and process 5. Plant arrangement considerations 6. Economic considerations such as plant maintenance expense 7. Considerations on plant survivability 8. Feedback from residents 9. Suggestions for future stormwater system design

most consistent with people's capacity to communicate by language (Seidman, 2005). We conducted in-depth interviews with experienced landscape professionals and pond managers. These interviews complemented the information obtained in the focus groups by focusing on the challenges of balancing aesthetic preferences of homeowners with required environmental function. Two landscape designers and two pond managers from the region were each interviewed for 1 h. The large amount of information gathered in the four professional interviews was sufficient for this study because no new information was being offered by the fourth interview. Professionals were interviewed for their experience and knowledge, which was not represented in the focus groups, to gain a more holistic view of pond issues. The interview focused on issues with shoreline plantings, such as codes and restrictions, design, survivability, maintenance expense, and homeowner's requests. Professionals also made recommendations for designing ponds in the future. The landscape professional interviews were audio recorded and reviewed. Interview comments from the professionals were linked to themes established in the focus groups and comments between the two groups of participants were compared.

REGULATORY CODE STUDY. Because regulatory codes can have significant influence on design and management of ponds, a reportorial study (review) of codes was used to learn about the legal perspective. Local codes from municipalities with

populations more than 300,000 (based on the 2010 U.S. census) were selected from a website that contains a database of municipal codes (Municipal Code Corp., 2013). Codes from 46 municipalities that included either landscaping or engineering criteria for stormwater ponds were selected for final analysis. Among them, 80% of the municipalities were in four southeastern states: Florida, Alabama, Tennessee, and Georgia. Items identified in the regulatory codes were recorded in a spreadsheet and linked with themes, including aesthetics, maintenance, and environmental, from the professional interviews and focus groups.

Results

Results are presented as the themes and subthemes (Table 2), from the coding process of the focus group transcripts, the interviews, and the code review. Major themes that emerged from the transcript coding process included aesthetics (the visual appeal of the plant material on the shoreline and the ability to see open water), management (maintenance plans that control algae, limit fertilizer, and maintain visual appeal of plants), knowledge (understanding pond and plant function as it relates to management and algae reduction), economics (maintenance funding and property value as it relates to visual appeal of the pond), nature (wildlife habitat to attract desirable wildlife such as birds), planting design (appropriate plant material and visually appealing arrangement), engineering design (pond morphology and water quality and quantity control), and

regulatory codes (management responsibilities, engineering, and desired visual appeal). Subthemes within the themes represent specific topics related to the themes. The themes were ranked in order of most comments to least comments (Collier and Scott, 2010) for the focus groups and professional interviews, and most citations to least citations for the code review (Table 3). The most important issues that emerged from the transcripts and code reviews included aesthetic preferences for landscapes and plants, wildlife as an amenity, algae and nutrient control, maintenance costs, and design issues. Many of the issues are addressed in one or more themes illustrating the interconnection of the issues.

AESTHETIC PREFERENCES. Aesthetic preferences for well-manicured, turfgrass landscapes around the home were also projected on shorelines and ponds. These preferences were supported by community landscape codes and restrictions and normative expectations of neighbors. Most ponds were landscaped the same way. Plants were typically not preferred, even in the water. These shared aesthetic standards meant that algae and submerged aquatic vegetation were seen as a nuisance and devalued their landscapes. Residents were aware that their landscape contractors were possibly contributing to nutrient overloading in the stormwater pond system but did not prioritize this among solutions to problem ponds. Their pond preferences were open views of the water, low vegetation on the shoreline, and attractive, flowering aquatic plants. In short, the

Table 2. Eight major themes and 40 subthemes emerged from the coding process of the focus group transcripts, the professional interviews, and the stormwater pond code reviews by organizing segments of text into related categories.

Themes	Subthemes
Aesthetics	Plant flower, shoreline aesthetic conflict, well-kept landscape, clean water appearance, open water view, plant leaf color
Management	Maintenance plans, plant control (invasive plants and weeds), nutrient–organic pollutants, nutrient–fertilizer control, algae control, shoreline low maintenance, fertilizer application certification, plant harvesting, water fluctuation
Knowledge	Pond and plant function, nutrient connection to algae growth
Economics	Maintenance funding and stormwater fees, property value, consistency of maintenance funds
Nature	Wildlife and habitat (desirable wildlife), natural setting (landscape style), undesirable wildlife
Design (planting)	Native plant, plant species, littoral zone size and depth, plant arrangement, plant variety, plant size (with height), littoral zone location
Design (engineering)	Sediment and erosion control, stormwater quantity control, bank slope, water quality control, pond depth, pond layout, forebay and pretreatment, aeration
Regulatory codes	Landscape social marketing program, littoral zone maintenance responsibility

Table 3. Eight major themes ranked by the number of comments, from most often mentioned to least mentioned by the focus group participants and professional interviews, and ranked by the number of citations in the code reviews from most cited to least cited.

Homeowner focus groups, no. of comments cited in each theme by 38 participants	Professional interviews, no. of comments cited in each theme by four participants	Code review, no. of citations in each theme in 46 codes
Aesthetics, 113	Design (plants), 58	Design (engineering), 204
Management, 81	Management, 35	Management, 90
Nature, 53	Aesthetics, 24	Design (plants), 71
Knowledge, 41	Design (engineering), 12	Economics, 39
Design (plants), 40	Economics, 10	Nature, 21
Economics, 34	Regulatory codes, 10	Knowledge, 21
Regulatory codes, 31	Nature, 9	Regulatory codes, 11
Design (engineering), 29	Knowledge, 9	Aesthetics, 4
Total comments, 422	Total comments, 167	Total citations, 461

ponds must conform to the standard landscape of the master-planned community.

Aesthetic preferences and their role in neighborhood expectations were notably absent in the code study. Results showed that few codes addressed aesthetic concerns and instead focused on engineering and management. Some addressed planting design requirements, such as plant species, spacing, arrangement, variety, and size (mostly height) but did not provide guidance on color or designs that would be more appealing to residents. Although some codes required colorful plants, the Farragut, TN Code of Ordinances (§ 4-XII) states “At least forty (40) percent of all plant material shall have a flowering component.”

POND MANAGEMENT, REGULATORY CODES, AND ECONOMICS. Most of the comments from designers and managers were associated with the difficulties of planting design and pond management. Their first priority was improving environmental function and the aesthetic preference of homeowners was second. Professionals commented on the difficulty of meeting homeowner preferences for open water views and achieving their own management goals of creating and maintaining habitat for wildlife and improving water quality. Making changes to pond landscaping to incorporate more diversity was viewed as difficult, given the limited acceptable plant choices, the lack of experience related to maintenance when compared with the original turfgrass landscapes, and the unknown cost of maintenance. Some codes have provisions for maintenance funding, for example, the Orange County, FL

Code of Ordinances § 34-291 states “The HOA (homeowner association) must deposit each year into the capital-repair/drainage pond account an amount sufficient (For landscape maintenance).” Limited maintenance funding was a concern for both designers and managers; they noted there was always aesthetic maintenance needed to meet visual quality concerns of homeowners. Homeowners also linked pond management to aesthetic value commenting that “They (pond managers) are here for a reason, and the reason is the beauty.” More than half of the codes included maintenance funding or stormwater fees and a few addressed property values. Biodiversity and wildlife were mentioned in codes as related to the design aspect of stormwater ponds and both features figured prominently in homeowner preferences. Pond design standards were primarily engineering requirements, with sediment and erosion control mentioned most often.

NATURE, LANDSCAPE DESIGN, AND KNOWLEDGE. Homeowners showed an acceptance of more diverse species than just turfgrass to the edge of the pond, although they still wanted an orderly look with colorful plants and some turf. They also had many concerns about the propensity of plants in Florida to quickly get out of hand. This could lead to a “weedy” or unkempt look. Participants in the focus groups were enthusiastic about flowering plants, and the designers and managers also liked to include color in their plans such as wildflowers. The municipal code of Maitland, FL (§ 8-14) encouraged use of a variety of plant species in shoreline areas: “Property owners are encouraged to plant a variety of different aquatic species to promote biodiversity.”

The view of the water also revealed a contrast between homeowners and managers: homeowners in the focus group preferred a clear view of pond water with no tall plants blocking the view. Managers were limited by plant height restrictions. Thinning and clearing plants to improve visual appeal of the pond means higher labor costs and a reduction in the amount of plant cover on the shoreline. One technique mentioned by a designer was to reduce weed growth through plant density. On a positive note, most buffer plantings were recognized by participants as somehow improving water quality. A few stormwater codes also recognized the issue; the Sarasota County Code of Ordinances (Environmental Technical Manual) included a statement on littoral zones stating, “Littoral zones should be located away from residential lots whenever possible ... perimeter or fringe littoral shelves are discouraged,” and “littoral zones ... shall be concentrated near the outfall of each pond when practical.”

Although pond health was a concern with both groups, the topic of algae growth produced emotions among homeowners. Homeowners were very vocal about the algae problems in the ponds, saying “When our lake gets bad ... you can look out and see masses of this stuff (algae) floating.” Others said, “It’s a beautiful view—except for the algae”; “it looks terrible and it leaves a very unfavorable impression.” A few participants noticed the connection between fertilizer application and algae growth, saying “additional nitrogen getting into the lakes is a tremendous growth affect for the algae.” Homeowners were willing to decrease algae with a small increase in plants (“why can’t

we have little ... separate beds or areas along the lake where you would have ... flowers”) but professionals felt more plants were a viable solution to the algae. One landscape code from Gainesville, GA (Code of Ordinances § 9-13-12-27) characterized algae as a nuisance: “All on-site facilities shall be properly maintained by the owner in such a way that they do not become nuisances. Nuisance conditions shall include ... stagnant water with algae growth.”

Both groups desired to see wildlife which created an alignment that could prompt the use of a greater variety and number of plants. Participants in the focus groups had several comments on wildlife, including “I just love living on the pond because you see all different kind of birds,” and “I’m all for that, diversity and wildlife. They are a part of why you have a pond.” One resident also associated wildlife with aesthetics, saying “We like sitting out there and looking out over the water ... the birds, the herons and egrets... It’s a wonderful, aesthetic kind of ... pleasing atmosphere.” Managers and designers also mentioned wildlife: “There were a few plants, excellent plants that would be great for wildlife as a part of the natural system.” The municipal code of Maitland, FL (§ 8-14) mentioned the function of shoreline plantings for wildlife watching: “littoral zone vegetation add to the natural beauty of lakes, wetlands, and other water bodies as well as provide means for passive recreation such as fishing, bird watching, and other activities.” Some municipal codes tell how to use design techniques to promote the wildlife value of the site. It was suggested that wildlife viewing areas could be integrated into pond design. The municipal code of Gainesville, FL (§ 30-253.2) said “the contour of retention and detention basins should promote aesthetically pleasing site design and increased wildlife habitat.” Wildlife habitat can be improved with pond configuration; wider, gently sloping littoral edges, and cleaning forebays provide good habitat for wading birds and amphibians, whereas deeper water can support more fish. This configuration would require more plant material in the shallow water which is generally not supported by homeowners; however, the deeper center may help improve

water quality. Although configuration is important, it is generally not an option for existing ponds as reshaping the pond would also reshape the property boundaries of lots around the pond perimeter.

Discussion

The goal of the analytical approach was to identify environmental and aesthetic alignments and conflicts between the themes identified in the focus group data. The information collected in the in-depth interviews and the code reviews highlighted the contrasting policies and actions taken by landscape managers to address stormwater pond function and still satisfy aesthetic preference of homeowners. The lessons learned from studying aesthetic preferences, social norms, maintenance practices, and code restrictions have implications for plant choice and planting design for proposed alternative landscapes.

One obvious point of contention that became evident in this research is the aesthetic landscape norms and regulations of the master-planned community. Landscapes in this study include a majority of turfgrass and most ponds had turf to the shoreline and few littoral or aquatic plants. The restrictions of codes and neighborhood norms (Nassauer et al., 2009), limits changes to the landscaping and will reduce the likelihood of implementing a wildlife friendly habitat.

When residential landscapes and common areas have a majority of turfgrass and are well cared for and uniform, there is often a similar aesthetic preference for stormwater ponds. This aesthetic preference creates another point of contention when participants do not agree on the amount of vegetation around the pond or how that plant material should look or be maintained.

We recommend that the aesthetic quality of shoreline plantings be emphasized in the design process so that these plants are welcomed by residents in the neighborhood setting. Residents frequently stated that landscapes should not look overgrown or neglected; they responded positively when they saw “cues to care,” meaning indications of upkeep in a landscape (Nassauer et al., 2009). Colorful flowers can enhance visual appeal of new landscape styles and may increase people’s acceptance of

them (Dunnet, 2010). Further, Nassauer (1997) noted the presence of flower colors could provide a sense of care and flowering plants are a positive link for attracting birds and pollinators. Other studies show invertebrate communities in bio-retention swales were affected by the quantity of flowering plants (Kazemi et al., 2011). Church (2015) found that rain gardens in Portland were perceived as more natural and being aligned with their environmental functions as wildlife habitat, compared with green streets. These studies support the association between aesthetics and environmental function.

Another point of contention is the true usefulness of plants in removing nutrients. Some scholars state that increased plant species diversity does not necessarily result in higher nutrient uptake rates (Liang et al., 2011; Petersen et al., 2015), whereas others argue plant species richness does positively affect nutrient removal (Cardinale et al., 2011).

A third issue that will affect implementation of diverse shoreline planting is the need to manage all ponds within the larger community. Reducing algae growth and achieving long-term water quality management depends on controlling nutrient input at the watershed scale rather than the shoreline area only (Heisler et al., 2008; Hurley and Forman, 2011; Serrano and DeLorenzo, 2008). The issues surrounding stormwater pond maintenance begin with fertilizer used to maintain the turfgrass to the quality desired by homeowners vs. the need to minimize nutrient runoff into the entire stormwater system and eventually into the ponds. Several studies have noted that maintenance of landscape vegetation can provide visual appeal and an environmentally healthier landscape (Apostolaki et al., 2006; Gobster et al., 2007).

Our study also agrees with Adams et al. (1984) and Walker et al. (2013) that stormwater ponds are associated with property values in neighborhoods, a common subtheme in our study. Homeowners were adamant about keeping the neighborhoods well maintained and green, stating “it is very important to our property value. Both the grass and the pond, right, because it’s a selling point.” Participants also emphasized the importance of property value

when talking about solutions to yard and pond problems, saying “we’re never going to do anything that’s going to lower our property value.” The use of plants in the ponds is often perceived as high maintenance and costly and if the new landscape is unsuccessful, it could affect property value. We recommend that designs for modified landscapes (including stormwater pond areas) include maintenance needs and account for unexpected costs (Apostolaki et al., 2006; Backhaus and Fryd, 2013).

The high-value homeowners attached to wildlife on their ponds is an opportunity to promote a nature-based aesthetic in areas of high ecological value through enhancing biodiversity and the use of man-made features. Previous studies have shown that residents living with stormwater pond landscapes considered the view of wildlife, and ponds designed to promote wildlife, to be particularly important (Adams et al., 1984; Bastien et al., 2012; Walker et al., 2010). In research by Nassauer (2004), the richness of bird species was found to be associated with landscape visual quality in urban wetlands, whereas the richness of plant species was not.

We recommend improving wildlife habitat to create a sense of custodianship of the stormwater pond (Walker et al., 2010). Stormwater landscape designs that link stormwater management to other functions such as wildlife habitat and recreational values seem to result in successful and integrated designs (Backhaus and Fryd, 2013). We suggest SCMs are valuable resources to construct nearby nature, for biodiversity as well as long-term stormwater pond management. When people have daily contact with diverse plantings and wildlife, they tend to care about them (Beatley, 2011) and be more aware of the impacts of management practices on the SCMs (Walker et al., 2013). One participant noted the trade-off of plants for wildlife saying “the pond next to us is loaded (with plants) and they’re complaining about how their water plants are taking over but we’ve still got this nice clear, clear water, clear pond. But we don’t get the birds that they get with the grasses so it’s a trade-off.” Another participant noted “I’d also assume that the more plants, the more diverse wildlife were

to come, starting with birds and all those other things.”

Limitations and future recommendations

Conducting the focus groups in communities where the stormwater ponds were similar may have limited the perception of the participants to a particular type of pond. Adding similar focus groups in other communities could add a different perspective to the study. The focus group interviews used snowball sampling and recruited residents interested in pond issues and governance of the HOA. Their involvement in these issues at the neighborhood level may lead to bias but it also indicates specific knowledge. The four professionals interviewed were known to the researchers and the number of professional interviews, although adequate, was low. It is recommended that more interviews be conducted if they are the primary source of information for a study. General surveys were not used as qualitative research methods can form a more holistic understanding of the situation through thematic/content analysis. Themes then provide a basis for developing and testing theories in future research. The information collected in this study will be useful for creating a general survey on aesthetics of pond landscapes, which could engage a greater number of homeowners and give more generalized results. The information from this investigation would also be useful in studies that investigate the quantitative aspects of shoreline planting design such as number and types of plants, size of plant gaps on the shoreline for open water views, and buffer widths for different shoreline types. Future research is needed to test design strategies for different pond shoreline types and quantify water quality improvements for planted shorelines.

Conclusion

This research used focus groups, in-depth interviews, and code reviews to uncover the relationships between social norms, management constraints, and design features. The primary relationships identified were conflicts and alignments between environmental landscapes and aesthetics

in stormwater ponds. The strongest alignment was the desire to see wildlife and the need to create wildlife habitat with shoreline plantings. People may be more likely to appreciate the use of plants and care for their yards in more environmentally sound ways if they know that the reward will be the opportunity to see wildlife. The greatest conflict was the differences in aesthetic preferences and the aesthetic norms for landscape in the community.

To promote best practices for stormwater pond function and wildlife aesthetics, homeowners and landscape managers must engage in a dialogue about whether to limit plant choices, how to pay for maintenance, and how to decrease nutrient runoff from the surrounding landscapes. They must understand the designs and the codes that created these man-made structures as well as the utility of maintaining biodiversity in a well-manicured landscape. Increasing biodiversity through planting design, maintenance, and protecting water quality should make ponds function better and attract more wildlife. The implication of this study is that by improving design and planting techniques, vegetation in SCMs may be accepted to provide social and environmental benefits.

Literature cited

- Adams, L.W., L.E. Dove, and D.L. Leedy. 1984. Public attitudes toward urban wetlands for stormwater control and wildlife enhancement. *Wildl. Soc. Bull.* 12:299–303.
- Armson, D., P. Stringer, and A.R. Ennos. 2013. The effect of street trees and amenity grass on urban surface water runoff in Manchester, UK. *Urban For. Urban Green.* 12:282–286.
- Apostolaki, S., C. Jefferies, and T. Wild. 2006. The social impacts of stormwater management techniques. 13 Jan. 2017. <<http://core.ac.uk/download/pdf/260889.pdf>>.
- Autixier, L., A. Mailhot, S. Bolduc, A.-S. Madoux-Humery, M. Galarneau, M. Prévost, and S. Dörner. 2014. Evaluating rain gardens as a method to reduce the impact of sewer overflows in sources of drinking water. *Sci. Total Environ.* 499:238–247.
- Backhaus, A. and O. Fryd. 2013. The aesthetic performance of urban landscape-based stormwater management systems: A

- review of twenty projects in northern Europe. *J. Landsc. Architecture* 8:52–63.
- Baptiste, A.K., C. Foley, and R. Smardon. 2015. Understanding urban neighborhood differences in willingness to implement green infrastructure measures: A case study of Syracuse, NY. *Landsc. Urban Plan.* 136:1–12.
- Barbosa, A.E., J.N. Fernandes, and L.M. David. 2012. Key issues for sustainable urban stormwater management. *Water Resour.* 46:6787–6798.
- Bastien, N.R.P., S. Arthur, and M.J. Mccloughlin. 2012. Valuing amenity: Public perceptions of sustainable drainage systems ponds. *Water Environ. J.* 26:19–29.
- Beatley, T. 2011. *Biophilic cities: Integrating nature into urban design.* Island Press, Washington, DC.
- Benvenuti, S. 2014. Wildflower green roofs for urban landscaping, ecological sustainability and biodiversity. *Landsc. Urban Plan.* 124:151–161.
- Cardinale, B.J., K.L. Matulich, D.U. Hooper, J.E. Byrnes, E. Duffy, L. Gamfeldt, P. Balvanera, M.I. O'Connor, and A. Gonzalez. 2011. The functional role of producer diversity in ecosystems. *Amer. J. Bot.* 98:572–592.
- Carlet, F. 2015. Understanding attitudes toward adoption of green infrastructure: A case study of US municipal officials. *Environ. Sci. Policy* 51:65–76.
- Castelle, A.J., C. Conolly, M. Emers, E.D. Metz, S. Meyer, M. Witter, S. Mauermann, T. Erickson, and S.S. Cooke. 1992. *Wetland buffers: Use and effectiveness.* Washington Dept. Ecol., Olympia, WA.
- Church, S.P. 2015. Exploring green streets and rain gardens as instances of small scale nature and environmental learning tools. *Landsc. Urban Plan.* 134: 229–240.
- Collier, M.J. and M. Scott. 2010. Focus group discourses in a mined landscape. *Land Use Policy* 27:304–312.
- Collins, K.A., T.J. Lawrence, E.K. Stander, R.J. Jontos, S.S. Kaushal, T.A. Newcomer, N.B. Grimm, and M.L. Cole Ekberg. 2010. Opportunities and challenges for managing nitrogen in urban stormwater: A review and synthesis. *Ecol. Eng.* 36:1507–1519.
- Corbin, J. and A. Strauss. 2008. *Basics of qualitative research: Techniques and procedures for developing grounded theory.* Sage, Los Angeles, CA.
- Dunnet, N. 2010. People and nature: Integrating aesthetics and ecology on accessible green roofs. *Acta Hort.* 881:641–652.
- Fletcher, T.D., W. Shuster, W.F. Hunt, R. Ashley, D. Butler, S. Arthur, S. Trowsdale, S. Barraud, A. Semadeni-Davies, J.L. Bertrand-Krajewski, P.S. Mikkelsen, G. Rivard, M. Uhl, D. Dagenais, and M. Viklander. 2014. SUDS, LID, BMPs, WSUD and more: The evolution and application of terminology surrounding urban drainage. *Urban Water J.* 12:525–542.
- Fraser, J.C., J.T. Bazuin, L.E. Band, and J.M. Grove. 2013. Covenants, cohesion, and community: The effects of neighborhood governance on lawn fertilization. *Landsc. Urban Plan.* 115:30–38.
- Gobster, P.H., J.I. Nassauer, T.C. Daniel, and G. Fry. 2007. The shared landscape: What does aesthetics have to do with ecology? *Landsc. Ecol.* 22:959–972.
- Guba, E.G. and Y.S. Lincoln. 1994. Competing paradigms in qualitative research, p. 105–117. In: N.K. Denzin and Y.S. Lincoln (eds.). *Handbook of qualitative research.* Sage, Thousand Oaks, CA.
- Guevara, Y. 2008. Beyond stormwater design considerations: When beauty and duty collide. MS Thesis, State Univ. New York, Syracuse, NY.
- Harper, H.H. and D.M. Baker. 2007. Evaluation of current stormwater design criteria within the state of Florida (final report). Florida Dept. Environ. Protection, Tallahassee, FL.
- Heisler, J., P.M. Glibert, J.M. Burkholder, D.M. Anderson, W. Cochlan, W.C. Dennison, Q. Dortch, C.J. Gobler, C.A. Heil, E. Humphries, A. Lewitus, R. Magnien, H.G. Marshall, K. Sellner, D.A. Stockwell, D.K. Stoecker, and M. Suddleson. 2008. Eutrophication and harmful algal blooms: A scientific consensus. *Harmful Algae* 8:3–13.
- Hurley, S.E. and R.T.T. Forman. 2011. Stormwater ponds and biofilters for large urban sites: Modeled arrangements that achieve the phosphorus reduction target for Boston's Charles River, USA. *Ecol. Eng.* 37:850–863.
- Kadlec, R.H. and R.L. Knight. 2008. *Treatment wetlands.* CRC Press, Boca Raton, FL.
- Kazemi, F., S. Beecham, and J. Gibbs. 2011. Streetscape biodiversity and the role of bioretention swales in an Australian urban environment. *Landsc. Urban Plan.* 101:139–148.
- Keddy, P. 2000. *Wetland ecology: Principles and conservation.* Cambridge Univ. Press, Cambridge, UK.
- Lewitus, A.J., L.M. Brock, M.K. Burke, K.A. Demattio, and S.B. Wilde. 2008. Lagoonal stormwater detention ponds as promoters of harmful algal blooms and eutrophication along the South Carolina coast. *Harmful Algae* 8:60–65.
- Liang, M., C. Zhang, C. Peng, Z. Lai, D. Chen, and Z. Chen. 2011. Plant growth, community structure, and nutrient removal in monoculture and mixed constructed wetlands. *Ecol. Eng.* 37:309–316.
- Lucke, T. and P.W. Nichols. 2015. The pollution removal and stormwater reduction performance of street-side bioretention basins after ten years in operation. *Sci. Total Environ.* 536:784–792.
- Mallin, M.A., S.H. Ensign, T.L. Wheeler, and D.B. Mayes. 2002. Pollutant removal efficacy of three wet detention Ponds. *J. Environ. Qual.* 31:654–660.
- Matthews, T., A.Y. Lo, and J.A. Byrne. 2015. Reconceptualizing green infrastructure for climate change adaptation: Barriers to adoption and drivers for uptake by spatial planners. *Landsc. Urban Plan.* 138:155–163.
- Moore, T.L. and W.F. Hunt. 2012. Ecosystem service provision by stormwater wetlands and ponds: A means for evaluation? *Water Resour.* 46:6811–6823.
- Morgan, D.L. 1996. Focus groups. *Annu. Rev. Sociol.* 22:129–152.
- Municipal Code Corp. 2013. Municode library. 20 Apr. 2013. <<https://www.municode.com/library/>>.
- Nassauer, J.I. 1997. Cultural sustainability: Aligning aesthetics and ecology, p. 65–83. In: J.I. Nassauer (ed.). *Placing nature: Culture and landscape ecology.* Island Press, Washington, DC.
- Nassauer, J.I. 2004. Monitoring the success of metropolitan wetland restorations: Cultural sustainability and ecological function. *Wetlands* 24:756–765.
- Nassauer, J.I., Z. Wang, and E. Dayrell. 2009. What will the neighbors think? Cultural norms and ecological design. *Landsc. Urban Plan.* 92:282–292.
- National Research Council. 2008. *Urban stormwater management in the United States.* Natl. Acad. Press, Washington, DC.
- Northeastern Illinois Planning Commission. 1996. *Shoreline buffer strips.* 25 Nov. 2012. <<http://www.epa.state.il.us/water/conservation/lake-notes/shoreline-buffer-strips/shoreline-buffer-strips.pdf>>.
- Petersen, J.E., E.C. Brandt, J.J. Grossman, G.A. Allen, and D.H. Benzing. 2015. A controlled experiment to assess relationships between plant diversity, ecosystem

function and planting treatment over a nine year period in constructed freshwater wetlands. *Ecol. Eng.* 82:531–541.

Seidman, I. 2005. Interviewing as qualitative research: A guide for researchers in education and the social sciences. Teachers College Press, New York, NY.

Serrano, L. and M.E. DeLorenzo. 2008. Water quality and restoration in a coastal subdivision stormwater pond. *J. Environ. Mgt.* 88:43–52.

Sisser, J.M., K.C. Nelson, K.L. Larson, L.A. Ogden, C. Polsky, and R.R. Chowdhury. 2016. Lawn enforcement: How municipal policies and neighborhood norms influence homeowner residential landscape management. *Landsc. Urban Plan.* 150:16–25.

Srivastava, J., A. Gupta, and H. Chandra. 2008. Managing water quality with

aquatic macrophytes. *Rev. Environ. Sci. Bio.* 7:255–266.

Tixier, G., M. Lafont, L. Grapentine, Q. Rochfort, and J. Marsalek. 2011. Ecological risk assessment of urban stormwater ponds: Literature review and proposal of a new conceptual approach providing ecological quality goals and the associated bioassessment tools. *Ecol. Indic.* 11:1497–1506.

Vincent, J. and A.E. Kirkwood. 2014. Variability of water quality, metals and phytoplankton community structure in urban stormwater ponds along a vegetation gradient. *Urban Ecosyst.* 17:839–853.

Vymazal, J. 2007. Removal of nutrients in various types of constructed wetlands. *Sci. Total Environ.* 380:48–65.

Walker, C., J. Lampard, A. Roiko, N. Tindale, A. Wiegand, and P. Duncan. 2013. Community well-being as a critical

component of urban lake ecosystem health. *Urban Ecosyst.* 16:313–326.

Walker, C., N. Tindale, A. Roiko, A. Wiegand, and P. Duncan. 2010. An ecosystem health approach to assessing stormwater impacts on constructed urban lakes. *Proc. 2010 Stormwater Ind. Assn. Natl. Conf.*, Sydney, Australia, 8–12 Nov. 2010.

Yang, H., W.A. Dick, E.L. McCoy, P.L. Phelan, and P.S. Grewal. 2013. Field evaluation of a new biphasic rain garden for stormwater flow management and pollutant removal. *Ecol. Eng.* 54:22–31.

Zheng, J., H. Nanbakhsh, and M. Scholz. 2006. Case study: Design and operation of sustainable urban infiltration ponds treating storm runoff. *J. Urban Plann. Dev.* 132:36–41.