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Evaluation of outreach and public education in raising awareness of waterfront community roles in controlling nonpoint pollution around the Mosquito Lagoon, Florida

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ABSTRACT

Nonpoint source pollution from residential areas is one of the potential factors for algal blooms in estuaries, which has cascading negative effects on estuarine water quality and ecosystems. The goal of this study is to assess the impact of public education on the roles of waterfront communities' in contributing and controlling nonpoint source pollution. Educational exhibits, workshops, and personal interactions with waterfront homeowners were conducted to raise awareness of surface runoff effects from waterfront yards on estuarine ecosystems. Pre- and post-surveys were used to evaluate the effectiveness of education methods. The study area was the northern watershed of the Mosquito Lagoon, FL. Survey results supported the idea that public education raises the public understanding of the importance of their individual actions on the ecosystem and water quality and demonstrates the importance of environmental education in watershed-scale ecosystem restoration.

Introduction

Coastal systems are being negatively impacted by increases in human populations, urbanization, and impervious surfaces (Chelsea Nagy et al. 2012). Human development increases impervious surfaces and alters the hydrology, which increases the amount of surface runoff entering a coastal water body from its watershed. Nonpoint source pollution occurs when surface runoff caused by rainfall or floods transport pollutants and carries a load of nutrients from land into nearby waterbodies. During periods with high rainfall, the nutrients are quickly carried by surface runoff, which can lead to algal blooms in coastal water bodies.

In recent years since 2011, the Indian River Lagoon (IRL), a 251 km-long estuary along Florida's Atlantic coast, has been negatively affected by a series of algal blooms. Nonpoint source pollution from residential areas is speculated as one of the potential factors for triggering those algal blooms (Bellamy and Cho 2019), which have cascading negative effects on water quality, growth of vital seagrass, and organisms that depend on seagrass. The IRL is an estuarine system composed of three interconnected sub-lagoons: Mosquito Lagoon (ML), Indian River, and Banana River. Continued human population growth and urbanization in this area increase the number of impervious surfaces, and these modifications of land use around the northern ML negatively affect water quality (Kroening, 2008).

Urban areas have measured a greater increase in nutrient and pesticide concentrations compared to undeveloped areas in national water quality tests. The construction of homes, apartments, and condominiums have negatively affected biodiversity, The Covenants, Conditions, or Restrictions (CCR) and the Homeowner Associations (HOAs) want to maintain uniform landscapes for aesthetics purposes and property values, therefore, requiring yard management using fertilizers and pesticides to keep green lawns, and reducing biodiversity due to intentional monoculture.

Native plants generally do not require as much water, fertilizer, and pesticides compared to the turfgrass commonly used in residential backyards because of their inherent adaptations to their native habitat and are more resistant to insects and disease than non-native plants (Koop-Jakobsen and Giblin 2010). Americans cumulatively spend around $750 million on grass seed and ~90 million metric tons of fertilizer annually; and an average ~8.7 m^3 of water is required per average household over the summer to stay green (Slattery et al. 2005). Employing more native plants rather than conventional turfgrass would reduce time, energy, water, and money. However, public perception of the benefits of having a waterfront backyard with shorelines planted with native wetland plants has been overlooked at residential properties.

The goal of this study is to assess the impact of public education on waterfront communities' perception of their roles in contributing to and controlling nonpoint source pollution in an estuarine ecosystem. The study area chosen for this research is within the ML watershed, a sub-lagoon of the IRL. This location was chosen because ML has suffered severe algal blooms since 2011 and is considered an estuary of high significance in the nation. To address the main goal, this project seeks to study two metrics of environmental awareness: the 1) knowledge and 2)

behaviors of the lagoon (Mosquito Lagoon) community as they pertain to environmental stewardship.

Materials and Methods

Surveys and outreach activities were conducted to (1) assess current knowledge and behaviors of the community in their contribution to nonpoint source pollution; and (2) measure how exposure to public education helps change their knowledge and willingness to change their behaviors. The following three public education methods were used.

Education through guided living shoreline exhibit tour

Living shorelines are a type of shoreline restoration method using native plants and other organic materials to buffer the number of nutrients from surface runoff before it enters a water body. Living shoreline exhibits at the Marine Discovery Center (MDC; 520 Barracuda Blvd., New Smyrna Beach, FL) display native coastal saltmarsh plants and oysters, terraces with native plants, retaining walls with native plants and oysters, seawalls with native plants and oysters, retaining walls with coquina rip rap and native plants, and coquina rip raps with native plants. We have conducted guided exhibit tours for one year to the visitors at MDC to educate various living shorelines to the visitors who attended the exhibit tours. The visitors who chose to participate in the guided tours, if agreed, were given pre-and post-survey questions on general knowledge and their current yard management practices that may affect estuarine water quality. Numbered pre-and post-surveys were given out to protect the confidentiality of people, but to match their pre-and post-survey results. Information given at the guided tour includes the current health of the lagoon, factors that affect the lagoon and drive algal blooms, effects of different types of shorelines including living shorelines on ecosystems, things a waterfront community can do to reduce nonpoint source pollution. A post-survey, with the same types of questions as in the pre-survey, but in a different order, was given at the end of the tour. Hereafter "guided living shoreline exhibit" may be referred to as simply "exhibit(s)."

Education through in-class workshops

In-class workshops were conducted to inform and educate the same information as above and assess their perception of their roles in controlling nonpoint pollution. Workshops were announced through newspaper articles and also through listserve emails sent from the partner organizations such as county libraries, universities, and MDC. Pre- and post-surveys were given out in the same manner as described above. The primary audience for these workshops was the general public living within and around the study area. Hereafter "in-class workshops" may be referred to as simply "workshop(s)."

Education through demonstration at waterfront properties

Owners of residential waterfront properties with their yard/lawn sloping into a water body were recruited within the ML watershed. These residential waterfront properties were selected for environmental education through the living shoreline/water quality assessment demonstration at their properties. Fund from the Environmental Protection Agency allowed the free installation of living shorelines and/or water quality/vegetation monitoring at the shoreline on their properties. The property owners were given the pre-survey before the start of the demonstration on their property and the post-survey 6 months after the pre-survey. Surveys for homeowners include the same questions for the surveys given at other education venues to compare the three education methods: (1) formal in-class workshop lectures, (2) field guided tours, vs. (3) informal, but personal interactions with homeowners over an extended duration (June-December 2017). Attending an in-class workshop or an exhibit tour was not required for the homeowners. There was a longer lapse time between pre-and post-surveys for the homeowners of about 6 months, whereas the workshop and exhibit tour pre-and post-surveys were done on the same day. Hereafter "waterfront property owners" may be referred to as simply "homeowner(s)."

Survey questions

The survey questions were grouped into two categories: (1) knowledge on the status and controlling factors of the lagoon health; and (2) yard management behavior if they have a yard. The survey data under the same category were grouped into questions sets (see below) for further analyses to compare the pre-and post-surveys, and to show if there are any changes in knowledge or the willingness to change behaviors to help improve the lagoon health (or the actual yard management behaviors by the waterfront property owners). The sets of surveys questions for the two categories, "Knowledge" and "Behavior", were as follows:

Question Sets: Knowledge Questions

1. Knowledge of the impact that waterfront homes have on the health of the lagoon.
2. Knowledge of the impact that "inland" homes (i.e., > 5 blocks from the lagoon) have on the health of the lagoon.
3. Knowledge of Florida friendly yard management practices and their impacts on the lagoon water quality.
4. Knowledge of the differences between natural shorelines vs. armored shorelines.
5. Benefits of using Florida native plants for waterfront yards as opposed to turfgrass.
6. Types of shorelines that provide the best habitat for wildlife such as waterfowl, juvenile fishes, crabs, and shrimp.
7. Knowledge of a living shoreline.
8. Knowledge of the impacts of fertilizers and herbicides applied to a yard have on water runoff into the lagoon.

Question Sets: Behavior Questions (The behavior questions were formalized to address the Volusia County's fertilizer ordinance: https://www.volusia.org/core/fileparse.php/5912/urlt/VCFertilizerOrdinance-508.pdf)

A. Do you (or your contractor for lawn maintenance) apply fertilizers to the yard?
B. If yes, how often do you apply them?
C. Do you apply during the summer (during the banned season)?
D. Have you applied herbicides to your yard within the last year?
E. If yes, how often do you apply them?
F. How often do you mow your yard during summertime?
G. What type of water do you use to water your yard?
H. If you water your yard, how frequently do you water your yard?
I. Do you water on a set schedule or when your yard is in need?

Data Analyses

The survey answers were converted to quantitative measurements for further analyses to compare the survey categories. Each question was scored from 0 to 1, with 0 being least environmentally aware (and/or friendly) and 1 being most environmentally aware (and/or friendly). Higher score values indicate the participant is more environmentally aware and/or would practice environmentally friendly yard maintenance, i.e. adherence to the Volusia County's fertilizer and the Florida friendly yard management practices campaigned by the Be

Floridian Now (https://befloridiannow.org/). Missing values or answers with "I don't know" were scored with 0. The questions that had a score of 1 in both pre-and post-surveys were separated from the main statistical analysis as this would give a false zero score (apparent zero gain in environmental awareness).

Descriptive analyses using survey scores were used to gauge current knowledge about the health of the lagoon and to assess the impact of public education on waterfront communities' perception of their roles in contributing to and controlling nonpoint source pollution in the estuarine ecosystem and their willingness to change their behavior.

There are two groups of observations: data sets containing pre-and post-data; and a data set containing data only from the pre-surveys. Exhibit surveys and workshop surveys contained behavior data only on the pre-surveys. The difference in pre-and post-scores was termed the "Change of environmental awareness index" or CEA index. For the sets that did not have post-survey data, only the pre-data was analyzed, and CEA was not obtained.

To test the effect of education method on the difference between pre-and post-scores and the components with only pre scores, a series of one-way permutational analysis of variance (paranoids) were conducted on each question set with education type as a fixed factor and scaled survey responses as the dependent variable in R using the "aovperm" from the package "permuco v1.0.2" (Frossard and Renaud 2019) with 99,999 permutations (i.e., lowest possible P-value = 0.00001). Any significant results were further analyzed with a series of pairwise perANOVAs between all paired education types with a Sequential Bonferroni correction as a post-hoc test. To test significant differences between pre-and post-scores, a paired permutational t-test was used to detect any significant deviation from 0.

Results

Demographics of public education participants

The number of survey participants for the education methods is the following: 110 for exhibit surveys, 12 for workshop surveys, and 20 for homeowner surveys. Fifty-five out of 110 exhibit survey participants were out-of-town visitors, whereas 60% of the workshop attendants were homeowners within the study area and lived in the same area for >15 years. Approximately 45% of the homeowners were the residents who have been living at their properties for less than five years. Approximately 80% of the survey participants from all education methods were 45 years old or older. For all education methods combined, 62% were female survey participants, and 38% were male survey participants.

Knowledge change

Understanding of the citizen's role and impact on local water quality was divided into three categories after assessment: 'no knowledge gained', 'knowledge gained', and 'knowledgeable before and after the information was given (being knowledgeable means a score of 1 in the same pre- and post-question).' Eight question sets were used to assess knowledge, and drawing upon all eight questions, across all education methods combined, 18% of survey participants did not gain any knowledge, 33% of survey participants gained knowledge, and 49% of survey participants had a general knowledge of the health of the ML before the education event. Broken down by the education method, >50% of the exhibit participants and homeowners were 'knowledgeable' before the education event (55% and 53%, respectively; Fig. 1). Exhibits and workshops showed 38 % and 42% in 'knowledge gained', while homeowners had the highest percentage of 'no knowledge gained' at 28% (Fig. 1).

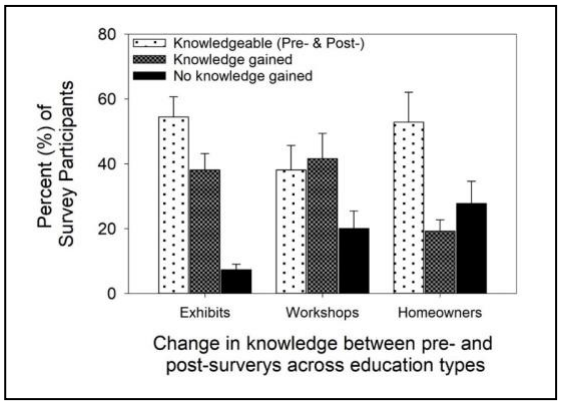

Figure 1. Knowledge change for each education method. Differences (in % of the total number of survey participants for each education method) in knowledge gain among the three education types. (Being knowledgeable means a score of 1 for each survey question)

At the individual question set level, results of a series of one-way permutational ANOVAs showed that there was a significant difference ($P \leq 0.05$) in the CEA Index (aka change in knowledge) among the three education methods for 5 of the 8 questions (Question sets 1, 2, 5, 7, 8). And among these questions, overall exhibits and workshops showed greater knowledge gained compared to homeowners ($p<0.05$).

Yard management behavior

Pre-survey responses to the behavior questions were compared among exhibit, workshop, and homeowner surveys. The results of a series of one-way perANOVAs showed that there was a significant difference in respondent scores among education types for question sets E, F, H, and J ($p \leq 0.05$). And among these questions, homeowners scored intermediate for question set F and lower for question set H, while workshop scored lower for question E but higher for question set F.

With pre-and post-data, 21% of homeowners implemented some sort of good environmental behavior change (Fig. 2); Good environmental behavior before and after means survey participants had a score of 1 in the same pre-and post-survey question), and approximately 41% did not change their yard management practices.

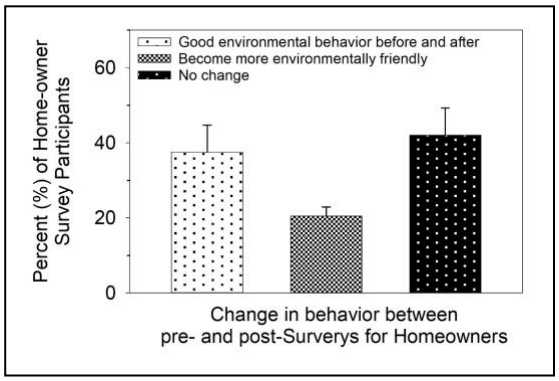

Figure 2. Environmental Behavior Index (pre-scores) for the 4 (individual questions G- J, see Section 2.3.5 in methods) across all education methods (Mean ± SE) are presented. Groups with significantly different Environmental Behavior Index ($P \leq 0.05$

after Sequential Bonferroni correction) are denoted with different lower-case letters.

Discussion

Environmental education can play a vital role in lessening the impact of a problem that can be caused by the community as previous studies agree that the most important outcome of environmental education should be to encourage people in more environmentally friendly behaviors. This research was conducted to (1) assess current knowledge and behaviors by the community in their contribution to nonpoint source pollution, and (2) to measure how exposure to public education helps change their knowledge and willingness to change their behaviors.

This research used three commonly conducted public education methods to evaluate which is more effective at knowledge gain and assessment in behavior in yard management practices by homeowners, which would help improve environmental quality at the watershed level. The education methods were designed to inform the participants about their roles and actions that can help reduce nutrient input into the ML. This study aimed to see if public education on living shorelines and nonpoint source pollution can change people's knowledge of their roles in the estuarine ecosystem.

Of the workshop survey participants, 42% gained knowledge; 20% did not have a positive change in knowledge (Fig. 1). Also, the exhibit tours turned out to be an effective educational method, as 38% gained knowledge and only 7% did not have a positive change in knowledge (Fig. 1). Survey participants from exhibit tours were exposed to tangible examples with the education topics, which made them more receptive to the information that was given to them. Previous education studies including Howie (1974) found that there are many benefits of outdoor experiences, but in-class environmental education is necessary for obtaining structured knowledge in the subject context.

The study participant demographics do not properly represent the regional demographics. For example, there was only one male in workshop surveys, as opposed to the fact 51% of the study area population were male and 49% were female according to the 2014 census data from the City-Data. Of all survey participants in this study, 82% were 45 years old or older. A study led by Digby (2013) also had that 73% of participants in her environmental behavior study were above 43 years old. This trend probably was resulted from the time of the workshops and exhibits (during the daytime and early evening) so that retired individuals or older homemakers would be more available to attend.

Current environmental awareness from the community in the study area needs improvement. Almost half of the survey participants were unaware of the current causes and problems of ML's health. Knowledge was lacking out ways the community can help to contribute to reducing environmental problems in the lagoon. Environmental education in this research had a positive effect on knowledge change of survey participants, and on environmental behavior change in yard management practices by some homeowners. Active participation and environmental education have been known to improve knowledge gain and awareness of the community about the causes and consequences of environmental issues (Tran 2006).

Conclusion

Assessment of current knowledge and behaviors of the community is important to evaluate the knowledge gained following environmental education. The assessment of current knowledge showed that almost half of the survey participants from all education methods were knowledgeable before we conducted the publication. Current behaviors on yard management practices were also assessed for: exhibit survey participants and workshop survey participants, approximately 40% of the participants practice good environmental yard managements. All three education methods, in-class workshop, guided exhibit tour, and informal demonstration at homeowners' backyards, were found to have a positive effect on the knowledge gain of survey participants. In-class workshops surveys were found to have the highest knowledge gain, followed by exhibit survey participants and homeowner survey participants. The Information also had a positive change in yard management behavior by homeowners. Overall, public education had a positive outcome on knowledge gain and behavior change. Overall, ~30% of participants had a better understanding and perception of waterfront community roles in how to contribute to and control nonpoint source pollution in the estuarine ecosystem, and to help improve water quality by implementing environmentally friendly yard management practices.

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