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Citizen Science a Tool for Community Engagement in Parks with an Urban Dominating Landscapes in Puerto Rico

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Abstract: With a population of 3.5 million on an island of 100 miles long and in severe economic crisis partners for the conservation of biodiversity is crucial for the sustainability of urban natural protected areas (NPA surrounded by large population centers, IUCN). The Conservation Trust of Puerto Rico (CTPR) is using citizen science (CS) an informal science education method to engage citizens in nature. While the conventional model for CS is a participant attending a workshop or training session, learn standard methodologies to measure and assess species, habitats and ecosystems from a scientist and then go off to collect data on their own and share data with the scientist, the CTPR propose an alternative model that includes the scientist with citizens, throughout the spatial and temporal long-term data collection. In this model, the citizens are mentored by the scientists or scientist assistant to pass through the different phase of the Informal Science Education model (contributory, collaborative, co-created). The main goal is to enable the citizens to develop the skills of scientific inquiry and to address environmental concerns within their community. Of the 1300 participants 19 have developed community based projects to better understand their environment and the impacts of urban development. The co-creator participants have used three levels of communication to disseminate findings of biodiversity in NPA along an urban gradient. The citizen science research projects conclude that urban protected areas play an important functional role in the watershed.

Key words: citizen science, urban dominating landscapes, natural protected areas

1. Introduction

For decades' governments and conservation organizations around the global are using environmental education to inform the public about the value of biodiversity and the ecosystems services provided by Natural Protected Areas (NPA). The educational experiences are mechanisms used to increase visitor's knowledge and reduce anthropogenic impacts within the NPA [1, 2]. The educational strategies and programs have included informative videos, conferences, self-guided, nature walks and tours to educate the public about the natural spaces, the species and ecosystems they contained, the threats facing them and what actions are taking place at local scales to protect them. In the early days of the Yellow Stone National Park for example, educational programs were initiated to better protect the park, its wildlife and its resources. Park programs, exhibits and literature educated visitors about the park's fragile ecosystem.

As early as 1920's, this NPA introduced citizen science to collected bird data within the Yellowstone National Park, park naturalist Milton Skinner completed the first Yellowstone Christmas Bird Count

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and continues today [3]. Today the educational programs involving citizens is wide ranging, from recycling programs to monitoring disease in wolves [4]. The educational programs at U.S. NPA and around the globe have evolved to include citizen science programs for the integration of research and hands-on experiences, bringing together different skills sets to find new solutions and deeper visitor connection with natural resources and the NPA [5, 6]. In Puerto Rico, however educational programs until recently remained conventional in NPA.

Puerto Rico is an island 111 miles long by 39.5 miles wide, in the Caribbean (Fig. 1) experiencing rapid urban development in both metropolitan and rural areas, resulting in loss of biodiversity, habitat loss and major environmental problems [7, 8], such as the impacts to main sources of freshwater from the karst regions of Puerto Rico [9]. The Rio Grande of Manatí Watershed (Fig. 1) is found within the northern Karst region, where there are increased proposals for urban developments in its nine municipalities: Orocovis, Barranquitas, Morovis, Ciales, Florida, Jayuya, Corozal, Manatí y Barceloneta. During focus group meetings held with volunteer leaders and watershed stakeholders, concerns included loss of biodiversity within the region, impacts to unique ecosystems (caves and underground rivers), reduced water quality, laws that do not take into account the importance of the karst, uncontrolled land use, and deterioration of local roads. Non-profit organizations of the area have engaged in efforts to increase public awareness on these impacts through dissemination of information, but citizens feel that they do not have the full spectrum of scientific knowledge or the tools to address the issues that are significant to them. Research shows that engaging people directly with research helps them become comfortable with tools and practice of science [10].

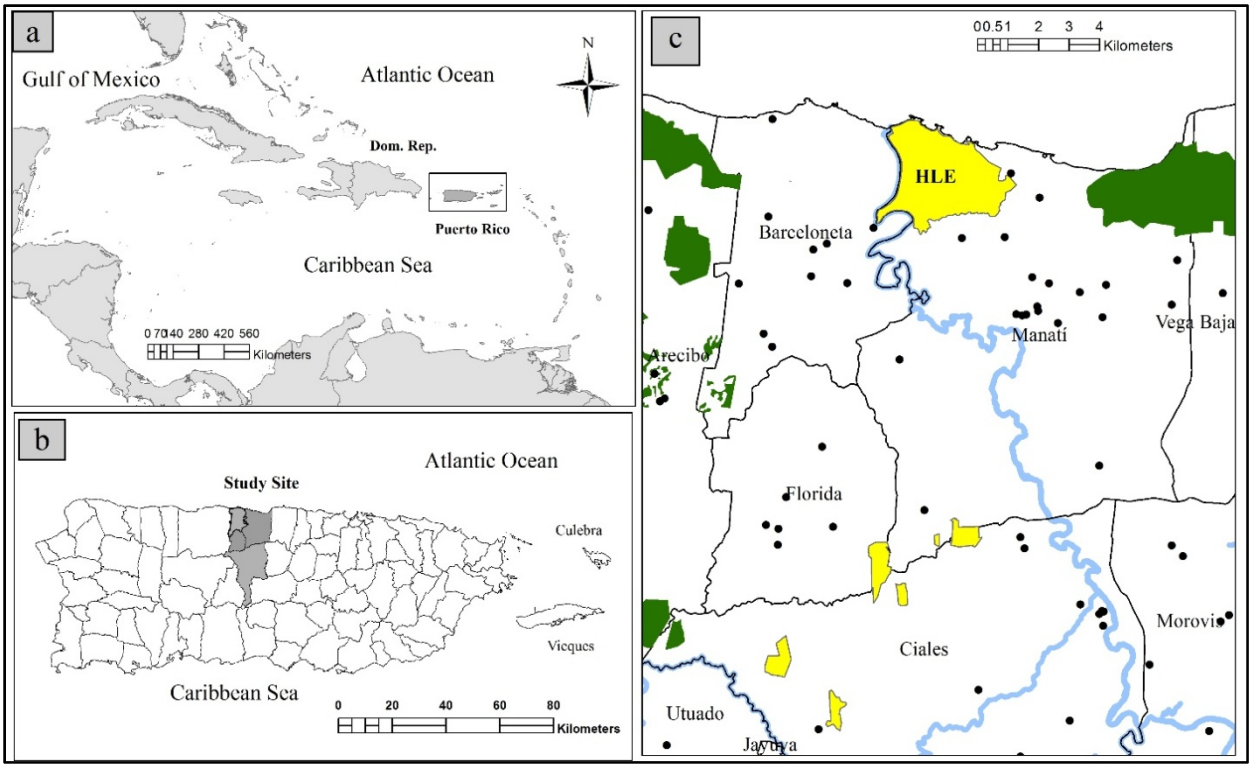

Fig. 1 Map Showing a) Location of Puerto Rico in the Caribbean, b) Study site in the northern coast of Puerto Rico c) Landscape of the Rio Grande of Manatí Watershed. Yellow polygons show natural protected areas managed by Para la Naturaleza and green polygons showing state managed natural protected areas. Black dots represent schools within the watershed as an indicator of urban development.

The Millennium Ecosystems Assessment (2005) shows that citizens who become significant actors in their environments play important roles in decisions linked to the use of those areas. While Sheedy (2008) state that citizens knowledgeable of the areas that they live in develop a sense of ownership and engage in behaviors, initiatives, and processes that address their neighborhood affairs [11].

The Conservation Trust of Puerto Rico (CTPR) established in 1970 currently owns and manages Natural Protected Areas which is 1% of the 16% of lands under protection and conservation in Puerto Rico. Their mission is to protect and conserve ecological and culturally important natural areas where they use educational guided tours, summer workshops and school gardens as a tool to educate about 60,000 visitors annual about species, ecosystems and their protection in Puerto Rico. With immense pressure for development in the past decades within sensitive cultural and ecological areas and little public advocacy, the CTPR decided to explore Citizen Science as an option to deeply engage participants in conservation actions. At first through a National Science Foundation funded project, they invited citizens to document with scientist the biodiversity of a Natural Protected Area of Hacienda La Esperanza (Fig, 1). The purpose of the project, in the municipality of Manatí, was a means to create stewards of nature that not only receive facts through tours but carry out actions to participate in the protection and conservation in nature. The project was highly successful with the development citizen science hands on toolkits and where some 2,322 participants actively collected scientific data and 48% whom returned to the project. Of these participants many have become volunteer leaders of the CTPR and now actively advocate for nature protection and conservation.

Based on the success of the first project within a NPA and using the framework developed by Bonney et al. (2009) for engaging citizens in conservation of nature through informal science education (ISE) the research team present using citizen science as an educational model to engage citizens in learning and implementing scientific process as they pass through the three levels of the ISE model-contributory, collaborators and co-creators. In the contributory phase participants mostly collect and record data, in the collaborator phase participants collect data, analyze samples and data and in the co-creator phase participants choose and define questions of research, gather resources and information, develop hypothesis or explanations, design data collections methodologies, collect data, analyze samples and data, interpret data and draw conclusions, disseminate conclusions and translate results into actions.

In five ecological research projects the impacts of urbanization along the Rio Grande de Manatí (Fig. 1) was evaluated by comparing biodiversity and ecosystems functions and processes within NPA and in areas surrounded by or close to urban development. The research project on Bats, evaluated the impact of urban development on bat diversity, the archaeological project investigated how humans used the river and the forest for resources and modified the local environments, the shrimps and crabs project looked at the water quality along an urban gradient comparing rivers in NPA with urban areas, the birds and forest project investigated forest fragmentation due to urban development and the coastal process project looked at the changes to geomorphological processes due to urban development along the banks of the river. Besides collecting baseline data on biodiversity and ecosystem process the projects provided opportunities to participants to 1) gain scientific knowledge with a well renown researcher 2) develop community based citizen science projects that is relevant to communities surrounding NPA and 3) to develop skills to communicate scientific results from their project to the wider community. Researchers in each project encouraged all participants to repeat field activities and invited them to develop their community citizen science projects after they developed sufficient skills

and knowledge about the specific ecological theme.

Over 600 activities (workshops, field trips and laboratory) were provided to transform citizens towards the three levels of ISE participation. All participants were given the opportunity to learn scientific methodology and specific scientific information about biodiversity through democratic bilateral learning and teaching processes in field and laboratories. The experiences in workshops allowed scientists to provide repeat participants in depth explanations about the methods and equipment used to collect biodiversity and ecosystem data in NPA and urban areas, creating an environment for questions and answers so that doubts and uncertainty is reduced when in the field. In the field, researchers used various teaching techniques to engage the participant so they transformed to collaborators and co-creators.

The demographic profile of all subjects participating in the activities of the five investigations was analyzed. There was a participation of 1,337 subjects in five projects, 548 (59%) were male and 789 (41%) female. Participation was diverse by age from children, youth, young adults and adults. Majority of participants (56%) were grouped into categories of young people (14 to 18) and young adults (19-28 years) (Table 1).

The profile of the general population of the project volunteers in the areas of gender and age profile is relatively similar to co-creators and collaborators. Of the 1,337 total participants five participants reached collaborator phase and fourteen reached co-creator phase. There is a higher percent of people over 44 years in the co-creators group (32%), when compared with the general population.

Table 1 Age distribution of participants in citizen science in urban dominated landscapes.

Age (Years)	Participants N = 1125		Co-creators/collaborators n=19	
	f	%	f	%
1 to13	51	5	2	11
14 to18	178	16	4	21
19 to23	322	29	1	5
24 to 28	129	11	5	26
29 to33	62	6	0	0
34 to38	64	6	0	0
39 to 43	77	7	1	5
> 44	242	22	6	32

During the past two years' the 7 co-creator's projects were completed and 6 are still in progress and 1 dropout. Each co-creator worked with a scientist mentor to develop research questions of their interest, write a proposal and implement their project in their community. They were asked to actively disseminate the findings of their projects within various settings using different media from schools, community meetings, open house, universities, symposia and congresses. Each co-creator had to involve volunteers in their projects and document the hours they contributed. For the past year co-creator projects have contributed 1,098 hours in volunteer activities with members of the community in urban dominated landscapes both with NPA and in urban areas. Each project below describes the co-creator's projects and achievements

Daniel Rivera Luis Collazo: *Monitoring water quality in the Rio de Bauta*

Daniel Luis Rivera completed the project monitoring water quality in the Rio de Bauta, Orocovis. He was mentored by Dr. Concepción Rodríguez Fourquet for scientific rigor and methods[1].

Jose Figueroa Pesquera:

This co-creator together with Dr. Concepción Rodríguez Fourquet successfully conducted the filming of a documentary local ecological knowledge about the shrimping and the importance of conservation of the river Torre Negro in Ciales. Consequently, published in Facebook, Twitter and YouTube pages for the Conservation Trust as river fishing in Puerto Rico: tradition and wisdom[2].

[1] https://www.facebook.com/Ciudadano.Cientifico.Orocovis?fref=ts.

[2] https://youtu.be/vNWvR9C8x-Y.

Sandra Berlingeri, Manuel A. Garcia Vega, Manuel A. Garcia Berlingeri, Jose F. Garcia Berlingeri: Water quality monitoring project in river Indio, Morovis

The family Garcia Berlingeri mentored by Dr. Concepción Rodríguez Fourquetcompleted the water quality monitoring project in river Indio, Morovis. The results surprised the team to co-creators where they found waste water treatment plant did not contribute to high levels of *E. coli* found in the river and they attribute this to poor management septic tanks of their neighbors.

Kimberly Melendez Rodriguez: Monitoring birds in the State Forest of Monte Choca, Corozal

This 16-year-old co-creator working with scientist Jose Salguero Faría developed a bird census project to monitor bird in the State Forest of Monte Choca. In May 2015 in recognition of the work completed by Kimberly she was featured in the website "EnVuelo" in a documentary.

Ricardo Rodríguez Vélez and Laura Rodríguez Rodríguez: Bird census and educational project at Cueva Escalera, Florida. This team together with scientist Jose Salguero Faría developed a bird census project at Cueva Escalera.

Gladys Valentin Gonzalez: Effects of cyclonic systems that impact the north and west beaches of Puerto Rico. This co-creator mentored by Dr. Maritza Barreto Orta presented findings on April 21-25, 2015 at the annual meeting of the American Association of Geographers in Chicago, Illinois[3].

Jean Carlos Colón Bergollo: Comparing changes in beach profiles in two beaches of Culebra, Puerto Rico. Together with Dr. Maritza Barreto Orta presented findings of his project was shared with peers at the annual meeting of the American Association of Geographers in Chicago, Illinois[4].

Valeria Torres Lopez: Geomorphological changes of the beach at Ocean Park

This co-creator together with her mentor Maritza Barreto Orta shared findings in April 21-25, 2015 at the annual meeting of the American Association of Geographers in Chicago, Illinois[5].

Venus Andrea Hernandez Paez: Identify bat species present in the Northeast Ecological Corridor. This 14-year-old together with mentor Dr. Armando Rodriguez Duran have taken demystifying bats to the community. In October 28, 2015, she presented her work at the North American Symposium on Bat Research (NASBR) in Monterey, California and was invited on November 6, 2015 to offering an educational talk about bats in the office Wildlife Refuge of Vieques[6]. *Dereck González Pérez*: Identify bat species present in the Miraflores, Arecibo. Also a 14-year-old accompanied by his mother and mentor Dr. Armando Rodriguez Duran monitors using ANABAT the different bat species present in the Miraflores district of Arecibo located in the Northern Karts of Puerto Rico. He has contributed 133.50 volunteer hours since July 2015. On 28 October 2015, he presented results at the North American Symposium on Bat Research (NASBR) in Monterey, California.

Hector Rivera Claudio: Exploring the history and use of agricultural terraces in the Protected Natural Area El Cuco. Hector is working with his mentor Dr. Isabel Rivera Collazo. On 15 April 2015, he presented his Citizen Science at the conference of the Society for American Archaeology (SAA), California. He was also invited to publish his findings in the Journal American Archaeology. His article is currently in press.

Miguel Diaz Diaz: Effects of geomorphological changes on archeological deposits at Tierras Nuevas within the Hacienda la Esperanza. Used the methods learned during two different research projects within this citizen science project and combined them. He is mentored by two scientists Dr. Maritza Barreto Orta

[3] https://drive.google.com/file/d/0BwTAHd5SeNtWNXBCdFNBekxCZmM/view.

[4] https://drive.google.com/a/ciudadanocientifico.org/file/d/0BwTAHd5SeNtWX29LRVlzbG1UbGM/view?usp=sharing.

[5] https://drive.google.com/open?id=0BwTAHd5SeNtWb0JwVDRSUXRyYk0.

[6] https://www.facebook.com/photo.php?fbid=556459991178149&set=a.324874434336707.1073741828.100004424598058&type=3&theater.

and Dr. Isabel Rivera and has shared his results with peers on April 15, 2015 at the conference of the Society for American Archaeology (SAA), California and on April 20, 2015 at the Geological Society of America Conference in Chicago, Illinois.

During the progression of the citizen science project co-creators started communicating project finding is various forums. Initially collaborators and co-creators started teaching first time participants field activities including methodology to collect data, data entry and answering questions. As they grew with knowledge and confidence collaborators and co-creators accompanied researcher to local symposiums and community based conservation activities and science fairs. At the co-creator phase, once they developed their community based projects participants began presenting national and international forums with academic peers and to audiences who were experts in the respective ecological themes. The various communication mechanisms were categorized into 3 levels (1) Divulge (share with general public) (2) Diffusion (share with target audience schools, community conservation groups) and (3) Dissemination (share with other scientists in the field: experts) (Fig. 2).

The ability of co-creators to effectively communicate about their projects served as a bench mark to evaluate attitude of participants towards science and towards conservation. Majority (53%) of the activities where the co-creators presented targeted general communities to share their experiences but also to invite communities to become active in conservation of biodiversity and ecosystems. The success of the techniques used to educate citizens scientist in scientific methods, knowledge and skills is reflected on the ability of co-creators to present at national and international congresses with experts in the field (40%). Citizen scientists managed to impact community surrounding the urban natural protected areas through various media (Fig. 2).

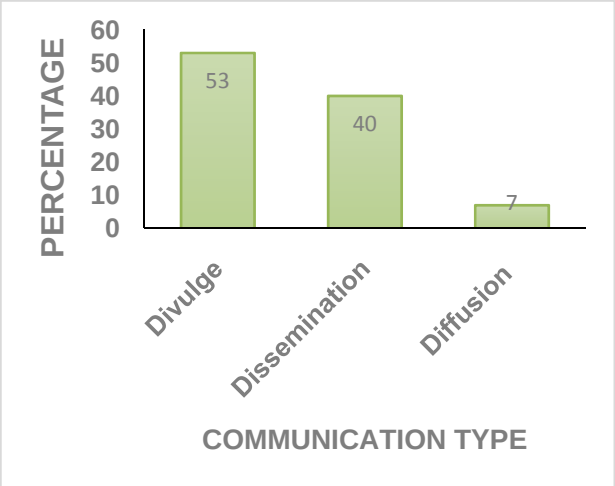

Fig. 2 Diverse means of communication used by participants in citizen science community projects.

2. Conclusions

Citizen scientists are important partners for NPA managers to engage communities to protect and conserve biodiversity and ecosystem processes. Repeat participation, bilateral communication during data collection and data analyses with a scientist is the cornerstone of engaging community members to develop science projects that is relevant to their social, economic and cultural context. Communicating experiences and results through diverse mechanisms for diverse audiences effectively educate about the impacts of urban development on biodiversity and ecosystems in NPA. The types of projects developed by citizen's scientists, the rigor of scientific process and time they dedicated to learn about their urban dominated landscape indicates the value of using citizen science as an educational tool in conservation.

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