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RESEARCH ARTICLE

Environmental awareness and willingness to pay for biodiversity improvement in Puerto Rico

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Abstract

Biodiversity is vital for sustainable forest ecosystems. However, community values for forest biodiversity depend on environmental engagement, education, and awareness. The objectives of this study are to (1) assess households' willingness to pay (WTP) for native plant and tree nursery in the Rio Hondo Community Forest (RHCF) of Puerto Rico, with the specific goal of supporting biodiversity and (2) examine the influence of environmental awareness on preferences for biodiversity improvement. Using a contingent valuation method, we find that households are willing to contribute $43/year to support biodiversity in the RHCF by planting native plants and trees, and that environmental awareness increases the support for biodiversity projects. The results suggest that outcomes of economic cost-benefit analyses can depend on environmental awareness. Hence, programs that support environmental awareness can improve economic efficiency of environmental protection projects.

Keywords Biodiversity · Contingent valuation · Environmental awareness · Puerto Rico · Willingness to pay

Introduction

Forest ecosystems offer a range of invaluable benefits that greatly enhance human well-being, including the aesthetic appeal of scenic beauty, the provision of essential ecosystem services, and the preservation of biodiversity (MEA 2005; Tavárez and Elbakidze 2019). Biodiversity, in particular, plays a crucial role in maintaining the health and dynamism of forest ecosystems, while also holding immense intrinsic value as a fundamental forest attribute. To ensure the long-term provision of ecosystem services and the sustainability of resilient forest ecosystems, community support of conservation and biodiversity management is imperative. One effective approach to enhancing regional biodiversity involves the establishment of nursery programs aimed at cultivating native plants and trees for subsequent planting in the surrounding forests (Lugo 2012; Mori et al. 2017). However, it is important to acknowledge that this strategy can be financially demanding, requiring careful economic analysis and valuation before its endorsement and implementation.

Environmental quality, including biodiversity, is a public good that can be degraded due to the absence of well-defined property rights (MEA 2005). Non-profit organizations, including government agencies, are essential for the provision of public goods. However, economic efficiency necessitates that the benefits of such public goods surpass the costs to justify public expenditures. Therefore, a thorough understanding of program costs and benefits is necessary for effective public management of environmental initiatives. While estimating costs for many environmental management programs and policies, particularly those associated with labor, materials, land, and equipment, is relatively straightforward, estimating the value of benefits is challenging due to their non-rivalrous and non-excludable nature.

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One widely used approach to assess the benefits of a policy aimed at providing non-market public goods is to estimate the population's willingness to pay (WTP) for those goods. In the realm of environmental quality and biodiversity specifically, community preferences can be influenced by familiarity and involvement in environmental protection efforts (Tavárez and Elbakidze 2021). Consequently, the benefits derived from enhancing environmental quality and the results of the benefit-cost analysis can be contingent upon the community's environmental awareness and attitudes.

The significance of environmental attitudes and awareness for non-market valuation has been demonstrated in prior literature. For example, using the New Ecological Paradigm scale, Kotchen and Reiling (2000) and Bartzak (2015) find that survey respondents in the USA and Poland with stronger pro-environmental attitudes are more likely to support and are willing to pay more for endangered species protection and forest improvement, respectively. The role of environmental awareness has also been documented in the context of consumer preferences for restaurant surcharge in support of carbon emission reduction in the USA (Long et al. 2021), farmers' willingness to participate in ecosystem protection in China (Min et al. 2018), and WTP for migratory bird protection in Netherlands (Brouwer et al. 2008). However, there is a lack of studies that examine the impact of environmental awareness on preferences for biodiversity improvement programs in regions outside of North America and Europe. We fill this gap by addressing this topic in the context of forest biodiversity improvement in the Rio Hondo Community Forest (RHCF) in Puerto Rico.

Interventions aimed at supporting endemic and native tree species in the forest can serve as an effective tool for educating residents and cultivating their appreciation for biodiversity and for the RHCF. RHCF visitor trail hikes include experimental enrichment planting activities featuring species such as *C. rugosa*, *D. excelsa*, *L. monosperma*, and *M. bidentata*, effectively functioning as educational opportunities (Cruz-Aguilar 2022). Similarly, enrichment plantings of edible fruit trees like avocado (*Persea americana*), breadfruit (*Artocarpus atilis*), cacao (*Theobroma cacao*), coffee (*Coffea arabica*), jácana (*Pouteria multiflora*), and jagua (*Genipa americana*) also have demonstrated the benefits of agroforestry practices (Abelleira 2019; Túa and Abelleira 2019).

The literature exploring the influence of environmental awareness and experiences on preferences for biodiversity in developing countries is scarce[1]. It remains unclear if environmental engagement and pro-environmental attitudes are significant factors for biodiversity preferences in a developing country setting. Tavárez and Elbakidze (2021) demonstrate the significance of environmental involvement and literacy for forest preservation preferences in Puerto Rico. They show that WTP to prevent the conversion of an urban forest to alternative land use depends on respondents' environmental disposition. We build on their research by investigating the willingness of households in Puerto Rico to pay for native plants and trees from a nursery in a local forest to improve biodiversity. Additionally, we explore the influence of environmental awareness on the preferences for initiatives focused on enhancing forest biodiversity.

Biodiversity refers to the richness and variability of genetic information and species at all levels of phylogenetic (e.g., protozoans, fungi, plants, animals) and ecological (e.g., community, landscape, region) organization. As defined by Redford and Richter (1999), "biodiversity refers to the natural variety and variability among living organisms, the ecological complexes in which they naturally occur, and the ways in which they interact with each other and with the physical environment." Biodiversity plays a crucial role in shaping the structure and functioning of ecosystems, which in turn influences the sustainability of species and genetic diversity (Connell 1978; Lavorel et al. 2013).

One notable example is the coevolution between certain tree species and animals that are attracted to flowers and fruits. These animals serve as pollinators or seed dispersers (Ricklefs 2001; Chazdon and Whitmore 2001). This symbiotic relationship between plants and animals contributes to an increase in tree diversity at new sites, consequently fostering a greater diversity of animal species that rely on these trees for food and habitat. Endemic, native, and introduced plant and animal species can also hold significant cultural, culinary, and economic value, further emphasizing the benefits associated with enhancing biodiversity (Hobbs et al. 2013; Lugo et al. 2020).

The significance of biodiversity has been recognized by not only natural scientists but also social scientists, leading to a steady growth in the literature on the economic valuation of biodiversity. Prior literature includes studies in developed as well as developing country settings. Jacobsen and Hanley (2009) report the results from a meta-analysis of WTP estimates for biodiversity conservation using forty-six contingent valuation studies across six continents. They conclude that society's wealth is a major determinant of WTP for biodiversity conservation. Christie et al. (2006) find that the public in England values most, but not all, aspects of biodiversity. However, there seems to be no preference for a pathway to biodiversity protection.

In a developing country setting, Do and Bennett (2009) estimate non-market values of biodiversity protection in a

[1] Puerto Rico has one of the highest human development indexes and one of the highest, if not the highest, gross product per capita in Latin America and the Caribbean (see UNDP 2022). In 2012, the human development index in Puerto Rico was 0.865. However, the inequality-adjusted human development index was 0.685, with human development patterns closer to Romania (0.687) and Croatia (0.683) (Fuentes-Ramírez 2014).

Mekong River Delta (MRD) wetland ecosystem. Using three different subsamples of Vietnamese households, depending on residence distance from MRD, they document significant net social benefits from biodiversity protection and advocate the use of contingent valuation methods in the developing country settings. Biénabe and Hearne (2006) measure WTP of foreign tourists and Costa Ricans for biodiversity conservation and scenic beauty using payments for environmental services. They conclude that both populations are willing to pay more for biodiversity conservation than for scenic beauty. Bhat and Sofi (2021) explore residents' WTP for biodiversity conservation in India using a contingent valuation method and find that residents are willing to pay $3.32/year for biodiversity conservation.

Revealed and stated preference-based methods have been widely used to estimate the value of non-market goods and services provided by terrestrial ecosystems, including forests (Ricketts et al. 2004; Pattanayak and Butry 2005; Barrio and Loureiro 2010; Johnston et al. 2017; Tavárez and Elbakidze 2019; Tavárez et al. 2021). Revealed preference methods rely on the observed data, whereas stated preference methods are based on choices made in hypothetical settings (Birol et al. 2006; Johnston et al. 2017). An example of revealed preference methods is hedonic valuation, which is based on the observed real estate transactions. This method assumes that property prices depend on the characteristics of the property, proximity to public areas and services (e.g., hospitals, schools, and parks), and environmental amenities. The tangible benefits of forests like recreation, scenic view, and noise reduction are likely to be captured in the property prices. However, less tangible benefits like carbon sequestration and habitat for biodiversity may not be captured in housing prices (Geoghegan et al. 2003; Engström and Gren 2017; Tavárez and Elbakidze 2021). Non-use bequest and existence values may also not be captured in revealed preference methods (Birol et al. 2006; Johnston et al. 2017). Thus, the value of non-market goods and services is likely to be underestimated in revealed preference-based methods.

Stated preference-based methods, including contingent valuation and discrete choice experiments, account for non-use values and can be applied in situations where real behavior data is unavailable. Both stated preference methods have been widely used to examine WTP for non-market goods and services, including forest benefits (Barrio and Loureiro 2010; Juutinen et al. 2014; Japelj et al. 2016; Tavárez et al. 2021; Tavárez and Elbakidze 2021). The contingent valuation is a convenient method to examine WTP for the combined characteristics of a project or policy as a whole, while choice experiments are convenient for evaluating trade-offs between project attributes.

The research questions in this study are as follows: do residents value biodiversity improvement in western Puerto Rico and if so, how large is the value? What are the factors that affect the value of biodiversity improvements? Does environmental awareness affect the value of biodiversity improvements and, consequently, economic viability? Focusing on the RHCF in western Puerto Rico, we estimate households' WTP for increasing biodiversity using native plants and trees cultivated from a local nursery program and examine the effect of environmental awareness on WTP. We use a dichotomous choice contingent valuation method because the focus of the study is on the evaluation of a particular project rather than attribute-specific effects. The instrument is designed to elicit resident willingness to make a financial contribution to biodiversity improvement efforts. We focus on native plants and trees as elements of biodiversity. At this stage, preferences are examined for qualitative rather than quantitative improvements in biodiversity. As an initial step of biodiversity valuation in Puerto Rico, we explore preferences for biodiversity improvement efforts in principle rather than for particular species and quantities. We find that WTP for biodiversity improvement via native plants and trees is statistically significant. Future research should examine WTP for particular species and/or quantitative increments in improvement.

Study area

This study was conducted in Puerto Rico, where exposure to hurricanes can lead to short-term biodiversity loss if conservation efforts are weak (Lugo 2008; Báez et al. 2021). In 2017, Hurricane Irma and Hurricane Maria wreaked havoc, with the latter causing a staggering $41 billion in economic losses (PR Planning Board 2018). The immediate focus was on restoring basic necessities like electricity, water, and roads, often spearheaded by local communities (Abelleira 2017; Lugo 2018; Rivera and Abelleira 2022). However, limited understanding of biodiversity's importance hindered the government's allocation of financial resources for forest recovery and management programs. In 2022, Hurricane Fiona also caused significant harm to communities, economies, and forest ecosystems. To enhance the resilience of Puerto Rico's forests against hurricanes and climate change, it is important to develop conservation programs that enrich forests with native plants and trees, thus increasing biodiversity.

Puerto Rico, a US territory since 1898, is an archipelago in the Caribbean consisting of a main island and several smaller islands. With a population of 3.2 million (US Census 2021), it is the smallest of the Greater Antilles. The main island spans 9104 km^2 and has experienced significant forest cover growth since the 1940s, primarily due to agricultural abandonment. Forest land now accounts for approximately 56% of the island's surface (USDA 2020). The RHCF is 27.5 ha (~68 ac) and is located in the Mayagüez municipality, in

Fig. 1 Puerto Rico and RHCF. The map in the upper left corner shows the location of Puerto Rico in the Caribbean. The map at lower left shows the municipality of Mayagüez (in red) on the main island of Puerto Rico and the location of the Rio Hondo Community Forest (green circle). The map on the right shows the roads that give access to the forest

western Puerto Rico (Fig. 1). This secondary forest naturally regrew after the decline of agricultural production in the 1970s.

The RHCF has a remarkable array of plant and animal species (Abelleira 2018; Rivera San-Antonio 2021). It contains at least 31 tree species, with 61% being native or endemic to Puerto Rico, and the remaining 39% introduced to the Archipelago. Species like *Albizia procera*, *Senna siamea*, and *Spathodea campanulata* dominate certain areas, having colonized former sugar cane and grazing lands approximately 50 years ago. Some of these introduced species, such as *A. procera*, are capable of biological nitrogen fixation, enabling their growth on sites unsuitable for other species. Additionally, small seeds or pods facilitate wind dispersal over long distances, aiding colonization of fallow lands (Francis and Lowe 2000). However, native tree species like *Cupania americana* and *Guarea guidonia* have also become dominant, dispersed through animals, particularly birds (Francis and Lowe 2000; Rivera San Antonio 2021).

The abundance of native and introduced species can be influenced by hurricanes, human intervention, and individual species responses (Connel 1978; Lugo et al. 2020; Báez et al. 2021). Conservation efforts in the forest can focus on enrichment plantings of native tree species adapted to the local climate, geology, and soil conditions, accompanied by management interventions like stand thinning. Enrichment plantings of endemic and native species such as *Coccoloba rugosa*, *Dacryodes excelsa*, *Libidibia monosperma*, and *Manilkara bidentata*, which historically occupied lowlands before deforestation, can enhance the conservation value of the RHCF (Wadsworth 1950; Weaver and Gould 2013; Cruz-Aguilar 2022). These species, which are scarce or endangered in Puerto Rico, provide flowers and fruits to pollinators and seed dispersers. Many endemic or native forest bird species (e.g., *Loxigilla portorricensis* and *Spindallis portorricencis*) have supported natural seed dispersal (Lugo et al. 2012; Abelleira 2018). Enrichment plantings and stand management that favor endemic and native tree species with edible and attractive fruits can increase the diversity of birds and other animals.

Materials and methods

Figure 2 outlines the study's structure. We relied on literature and stakeholder input to identify preferences for biodiversity enhancement in the RHCF. This information guided the development of a survey instrument, including the contingent valuation and environmental awareness-related questions. The questionnaire underwent testing in focus groups and subsequent revisions. Using data from the contingent valuation method, we estimated residents' willingness to pay (WTP) for biodiversity improvement by planting native plants and trees in the RHCF and examined the effect of environmental awareness on WTP.

Ex ante information

We gathered insights from literature (Rivera-Acosta 2018; Rodríguez-Candelaria et al. 2018; Tavárez and Elbakidze

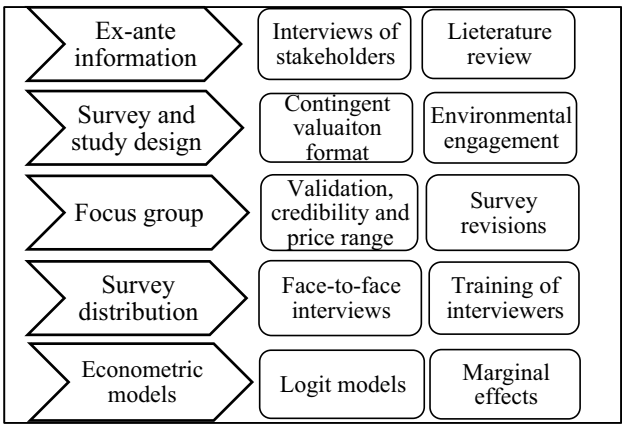

Fig. 2 Structure of the study

2021) and stakeholder interviews, including University of Puerto Rico (UPR) faculty members, community residents, and RHCF board of directors, to identify preferences for land use and economic development programs. Ex ante background information indicates residents' interest in various outdoor recreational activities, economic growth initiatives, and research opportunities originating from the forest. Environmental conservation programs that promote a sustainable forest for future generations were identified as important factors. While planting native plants and trees was not explicitly highlighted, increasing biodiversity emerged as a priority for residents and stakeholders. This information served as the foundation for developing the valuation exercise.

Survey and study design

The questionnaire was used to obtain primary data used in the estimation. It included two main sections. Section 1 contained the contingent valuation question and follow-up inquiries to gain insights into responses to the valuation exercise. Section 2 collected information on respondent sociodemographic characteristics (SDCs), such as age, gender, income, education level, and environmental awareness-related data. For instance, respondents were asked about their involvement in institutions focused on environmental conservation, their interest in volunteering for forest management, and their current participation in environmental management initiatives. Additionally, respondents were given the opportunity to provide comments on the survey and study design, including their experience with the valuation exercise.

The contingent valuation method is sufficiently versatile to be applied in different contexts and, therefore, has been extensively used for estimation of WTP for non-market goods and services. Due to the hypothetical nature of the valuation exercise, multiple criticisms have been raised, including hypothetical bias, embedding, and scope problems (Hausman 2012). Interviewer bias may be present in face-to-face interviews (Loureiro and Lotade 2005) and quality of information presented in the survey instrument can affect outcomes of CV studies (Ajzen et al. 1996). To address these and other limitations, researchers have developed and applied multiple strategies in empirical studies. These strategies include cheap-talk scripts, training protocols, identification of protest responses, and use of various valuation formats for cross-validation (Bateman et al. 2002; Jin et al. 2006; Tavárez et al. 2021). Guiding principles have been developed for better practices in using contingent valuation (Arrow et al. 1993; Johnston et al. 2017).

Contingent valuation is particularly useful in our context to obtain WTP estimates for a project as a whole, rather than evaluating trade-offs between project attributes, which would require the use of other methods. We used a single-bounded dichotomous choice contingent method because this format mimics transactions in the real marketplace, reduces outliers, and is incentive compatible (Bateman et al. 2002; Champ et al. 2003). In this format, respondents receive information about the nature of the problem, means to solve the problem, implementation mechanism, payment amount, and frequency of payment. The respondent can either support or oppose the proposed project with an associated cost (Bateman et al. 2002). After receiving the instructions and the information about the nursery for native plants and trees that would result in greater biodiversity, the respondents were asked if they would agree to pay the indicated amount to support the biodiversity improvement project, ranging from $5 to $150/year per household. Only one contingent valuation question was presented to each respondent. A cheap-talk script was included to reduce hypothetical bias (Cummings and Taylor 1999; Carlsson et al. 2005). The translated version of the contingent valuation question script is as follows:

> Native plants and trees are important factors for biodiversity. Land cover change and other human actions have reduced diversity. Even though there are projects aimed at conserving native plants and trees in Puerto Rico, more could be done to encourage preservation in the long term. The Rio Hondo Community Forest could be used as a nursery to germinate and later transplant some native plant and tree species in support of flora and fauna diversity in the region. Such a project will require an initial investment and labor costs to maintain the native species. The project will only be carried out if more than 50% of the residents are willing to pay support it. All households would pay the same amount.
>
> Assume that increasing biodiversity through native plants and trees from nursery programs in the Rio

Hondo Community Forest would cost $ AMOUNT per year per household. Would you be willing to support a policy that costs this amount per household per year to increase biodiversity in the Rio Hondo Community Forest?

We used follow-up questions to identify potential protest or otherwise unreliable responses to the valuation exercise, as suggested in prior stated preference-based literature (Bateman et al. 2002; Tavárez and Elbakidze 2019; Johnston et al. 2017). Particularly, respondents were asked to state the reasons for supporting or not supporting the biodiversity project. Additionally, we incorporated an open-ended contingent valuation question to inquire about the maximum monetary contribution the respondents were willing to make towards the augmentation of biodiversity in the RHCF via native plants and trees. There are two scenarios for identifying inconsistencies across the dichotomous choice and open-ended contingent valuation formats. First, respondents may agree to pay X amount in the dichotomous choice question but state a maximum WTP in the open-ended question that is less than X. Second, respondents may refuse to pay X amount in the dichotomous question but express a greater than X willingness to pay in the open-ended question. Such responses can be used to screen out potentially unreliable data. We conduct the analysis with and without these observations for robustness check.

Focus groups

Two focus group sessions were used to test the questionnaire and ensure its clarity, adequacy of length, and appropriateness of selected cost range. Each session lasted 2 h and included 8 and 12 participants. The first focus group included members of the RHCF board of directors and UPR faculty, and the second included residents who live near the forest. Best efforts were made to ensure diverse representation in terms of age, gender, and educational to account for preference heterogeneity. Overall, participants expressed no concerns with the questionnaire's clarity, length, and cost range. They emphasized the significance of recreational and environmental conservation-related initiatives, aligning with stakeholder input and literature findings. Some participants expressed interest in specific activities aimed at forest sustainability and income generation, such as the commercialization of forest-based goods and services, including food, workshops, and tourism-related ventures.

Survey distribution

The questionnaire was distributed through in-person interviews by three interviewers who were trained to reduce potential interviewer and information bias. The questionnaire was distributed to all available households surrounding the RHCF who were willing to participate[2], particularly to residents of the Rio Hondo ward. The questionnaire was distributed to encompass a radius of one mile from the RHCF, involving a significant portion of the ward's residents. The data was obtained during different days and times, allowing for preference heterogeneity across residents with diverse working schedules.

Theoretical framework and empirics

The contingent valuation method is based on random utility theory, which suggests that the individual utility is random but can be decomposed into observable and unobservable components (McFadden 1974). An individual supports the proposed project if the corresponding utility (V) obtained from the project after paying C is higher than the utility of the status quo with no additional cost (Hanemann 1984). In our context, the respondents support increasing biodiversity through planting native plants and trees if:

$$V\left(I-C,Q^1,S\right) > V\left(I-0,Q^0,S\right) \tag{1}$$

where I represents income, S is the SDCs of respondents, Q^1 represents the proposed project and Q^0 represents the status quo. If V (I, C, Q, S) is the observable component of utility, the probability of an individual voting in favor of the biodiversity project can be expressed as follows:

$$Prob(yes) = Prob\left(V\left(I-C,Q^1,S\right)+e_1 > V\left(I,Q^0,S\right)+e_0\right) \tag{2}$$

where e_i are unobservable components of utility. Assuming that e_i follow a logistic probability distribution, this can be expressed as follows (Greene 2012):

$$Prob(yes) = e^v/(e^v+1) \tag{3}$$

Assuming the utility function is linear and additively separable, the indirect utility function of alternative i can be expressed as follows:

$$V_i = \beta_0 + \boldsymbol{\beta S} + \beta_c C \tag{4}$$

where β_0 is a constant term, $\boldsymbol{\beta}$ and β_c are coefficients, $\mathbf{S}$ is a matrix of respondents' SDCs, and C is the cost. Median household WTP is calculated using the estimated coefficients as follows (Hanemann 1989):

[2] The questionnaire was intended to be distributed to every other house to reduce self-selection bias. However, recent crime activities and COVID19 resulted in lack of respondents willing to participate in an in-person interview.

Table 1 Explanatory variables for the regression models

Variables	Definition	Expected sign
Gender	Gender of respondent (1 = female, 0 = male)	?
Age	Age of respondent (21–90 years)	−
Education	Education of respondent (0 = none, 5 = graduate school)	+
Income	Respondent household income per month (1 = less than $500, 7 = $7000 or more)	+
Access	Proximity to the forest entrance (walking distance) (1 = less than 5 min, 4 = more than 25 min)	−
Active	Respondents who are currently active in environmental management initiatives (1 = yes, 0 = no)	+
Institutions	Respondents who have worked or studied in institutions that address environmental conservation (1 = yes, 0 = no)	+
Volunteering	Respondents who are willing to volunteer in forest management programs (1 = yes, 0 = no)	+
Awareness	If respondents are currently active in environmental management initiatives, have studied or worked in institutions addressing environmental conservation, or are willing to volunteer in forest management programs (1 = yes, 0 = no)	+

$$WTP = \frac{\beta_0 + \boldsymbol{\beta}\overline{\boldsymbol{S}}}{\beta_c} \tag{5}$$

where $\overline{\boldsymbol{S}}$ are the sample means of the SDCs, and β_c is the cost coefficient.

We used logit models to analyze contingent valuation data. In this model, the dependent variable is binary and indicates if the respondent votes in favor of the biodiversity project. The independent variables are the SDCs of individuals, such as age, gender, income and education. In addition, we included three variables related to environmental awareness: (1) whether respondents have experience working or studying in institutions focused on environmental conservation, (2) current involvement in environmental management initiatives, and (3) willingness to volunteer in forest management programs. These variables were included to capture respondents' engagement and commitment towards environmental conservation, providing valuable insights into their awareness and potential participation in conservation efforts.

We estimate three logit models. The first logit regression includes all the SCDs and environmental awareness-related variables (model 1). The second model is a result of a backward stepwise procedure with the reported model that only includes significant variables (model 2). Finally, the third model combines all environmental awareness-related variables into a single-binary variable (model 3). In the third model, the binary variable is one if the respondent answered yes to either of the three awareness related questions. Contrary to the first model that evaluates the effects separately, the third model allows us to evaluate whether any experience with environmental conservation programs or intentions to volunteer affect preferences for biodiversity improvement. We used the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) to assess relative model fit.

Table 1 shows the variables used in the regression models, with corresponding definitions and expected signs. According to the economic theory, we expect households with higher incomes are willing to pay more for the biodiversity project. Based on prior stated preference studies on local forest ecosystems (Tavárez and Elbakidze 2019; Tavárez et al. 2021), we expect a negative effect of age and a positive effect of education on WTP for the biodiversity project. We do not have an ex ante expectation for the effect of gender. Residents who live near the forest may be more willing to support the biodiversity project, as these residents obtain more benefits from the forest than those living farther away. All environmental awareness-related variables are expected to have a positive effect on the support for the biodiversity project.

We are interested in examining the factors that may predict environmental awareness. Understanding such factors may be useful for guiding the development of targeted strategies aimed at fostering environmental conservation within specific segments of the populations. Gaining insights into these factors can help identify effective approaches to encourage and promote environmental awareness among various groups. We employed a *t*-test to examine whether younger and/or more educated respondents are more likely to be involved in environmental management initiatives.

Data

A total of 208 respondents completed the questionnaire between July 2022 and December 2022. Thirty-seven residents refused to take part in this study, resulting in a participation rate of 85%, which is reasonable for face-to-face interviews (Bateman et al. 2002). Unfortunately, a spike in criminal activities in the region, combined with lingering concerns about the COVID19 pandemic, probably discouraged participants from engaging in face-to-face interviews. This limited the size of our sample as many households did

Table 2 Socioeconomic and demographic characteristics of respondents

Variables	Mean	Min	Max	Median
Gender	0.57 (0.50)	0	1	1
Age	61.13 (14.78)	21	90	64
Education	3.31 (0.78)	2	5	3
Income	3.10 (1.65)	1	7	3
Access	3.20 (0.98)	1	4	4
Active	0.11 (0.31)	0	1	0
Institutions	0.05 (0.22)	0	1	0
Volunteering	0.38 (0.49)	0	1	0
Engagement	0.41 (0.49)	0	1	0

Standard deviation is in parenthesis

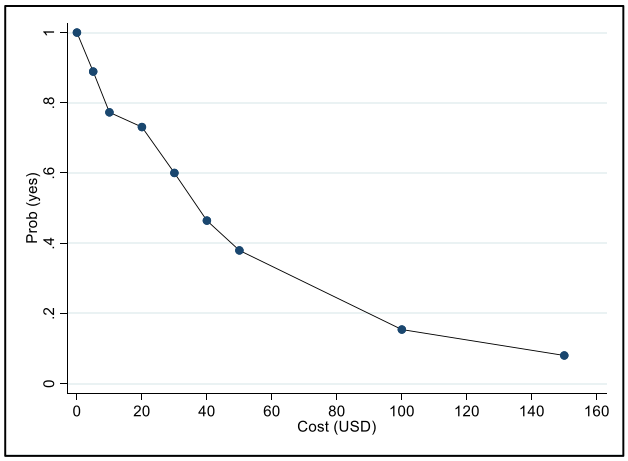

Fig. 3 Survival function of the distribution of votes across cost amounts

not open the door either because they were not home, were concerned about safety, or some other reason.

Eighteen respondents provided answers that suggested protest responses. Among these, three expressed concerns about the allocation of funds, sixteen stated that the government should pay for the biodiversity project, and one participant stated that the forest and its services should not be measured in monetary terms (a few participants stated more than one protest response). Nineteen respondents, 9% of our sample, provided inconsistent answers across contingent valuation formats. However, the regression results and WTP estimates are invariant to exclusion of inconsistent and protest responses. Therefore, we present the results using all observations. The results from the reduced sample are available upon request.

Table 2 shows SDCs and environmental awareness-related variables. Median age of respondent was 64 years, and 57% were female. Average respondent education was a high school degree. Median household income was $1000–$2000/month, equivalent to $12,000–$24,000/year. The median age of residents in the Rio Hondo ward is 50.2, which is higher than the population of Mayagüez but lower than our sample. However, it is difficult to compare the median age of our sample with the Rio Hondo ward, as minors are not considered in this study. The percentage of females and the median household income per year in the population of Rio Hondo is 59% and $18,177/year, respectively (US Census 2021). In terms of environmental awareness, 11% of respondents were currently active in environmental management initiatives, 5% of respondents have studied or worked in institutions addressing environmental conservation, and 38% of respondents were willing to volunteer for forest management programs.

Figure 3 shows the distribution of votes in favor of the proposed biodiversity project across bid values. The probability of supporting the biodiversity project decreased as the cost increased, which is consistent with the economic theory and prior contingent valuation studies (Lindhjem and Navrud 2011; Parsons and Myers 2016). The probability of paying $150 to support the biodiversity project was 7%. Poor experimental design may result in outcomes where the probability of supporting a project does not decline at higher cost amounts (Kerr 2000), posing doubts on the validity of results. In this regard, it is encouraging that in this study, the probability of supporting the project declines significantly at higher cost values.

Results and discussion

Table 3 shows the results from the three logit models with the corresponding marginal effects. According to the pseudo R^2, the models' fits are comparable to prior contingent valuation studies (Kotchen and Reiling 2000; Tavárez and Elbakidze 2021). The AIC and the BIC suggest that model 2, which is the reduced model following the backward stepwise procedure, fits the data best. Consistent with Fig. 3, the cost coefficient is negative and statistically significant, indicating that the probability of supporting the biodiversity project decreases as the cost increases. Income coefficient is not significant. Similar results in terms of insignificant income coefficients have been reported in prior contingent valuation studies (Casey et al. 2006; Akram and Olmstead 2011). The insignificance of the income coefficient may be the result of some respondents misrepresenting their income, which may occur in face-to-face interviews, and/or wealthier respondents preferring to invest in other more lucrative projects.

We find that access to the urban forest is statistically significant at 10%. The negative sign of the coefficient indicates that the probability of supporting the biodiversity project decreases as distance increases. The marginal effects suggest

Table 3 Logit models for the contingent valuation data

Variables	Coefficients for model 1	Marginal effects	Coefficients for model 2	Marginal effects	Coefficients for model 3	Marginal effects
Constant	−0.474 (1.342)	–	1.430 (0611)		−0.331 (1.322)	–
Cost	−0.031 (0.006)***	0.005 (0.001)***	−0.031 (0.006)***	0.005 (0.001)***	0.032 (0.006)***	0.005 (0.000)***
Gender	0.354 (0.350)	0.060 (0.058)	–	–	0.273 (0.345)	0.047 (0.058)
Age	0.018 (0.014)	0.003 (0.002)	–	–	0.018 (0.013)	0.003 (0.002)
Education	0.083 (0.271)	0.014 (0.046)	–	–	0.083 (0.270)	0.014 (0.046)
Income	0.081 (0.114)	0.014 (0.019)	–	–	0.080 (0.114)	0.014 (0.019)
Access	−0.176 (0.180)*	−0.030 (0.030)*	−0.157 (0.165)*	−0.028 (0.029)*	−0.209 (0.176)*	−0.035 (0.030)*
Active	0.938 (0.632)	0.158 (0.104)	–	–	–	–
Institutions	1.526 (1.057)	0.256 (0.175)	–	–	–	–
Volunteering	1.052 (0.389)***	0.177 (0.061)***	1.021 (0.340)***	0.180 (0.055)***	–	–
Awareness	–	–	–		1.340 (0.381)***	0.228 (0.057)***
N	208		208		208	
Pseudo R^2	0.28		0.25		0.26	
AIC	228.60		225.31		226.98	
BIC	261.98		238.66		253.68	

***Significant at 0.01, *significant at 0.10

that for one unit increase in the proximity to the forest (see Likert scale in Table 3), the probability of supporting the biodiversity project decreased by 3%. This result is expected, as residents near the forest can obtain more benefits than residents living farther away. For example, the residents near the forest can enjoy scenic beauty, lower temperatures, cleaner air, bird watching, and noise reduction.

The coefficients for active engagement with environmental initiatives and past education or work experience with environmental institutions are insignificant, while the coefficient for willingness to volunteer with environmental conservation programs is significant and positive. This result suggests that respondents who are willing to volunteer in forest management programs are more likely to support the biodiversity project. The marginal effect of volunteering indicates that the probability of supporting the biodiversity project is 18% higher for this group of residents relative to those who are not willing or able to volunteer. The awareness variable is positive and significant, indicating that involvement in environmental management initiatives is positively correlated with preferences for improving biodiversity. The marginal effect indicates that participants who answered yes to at least one of the three environmental awareness questions are 23% more likely to support the biodiversity project than those who did not.

We estimate WTP for biodiversity improvement using native plants and trees from a nursery in RHCF according to Eq 5. The results show that households are willing to pay $43/year for the biodiversity project in the RHCM (Table 4). The estimate is higher than prior stated preference studies on biodiversity in other regions (Christie et al. 2006; Bhat and Sofi 2021), which may be attributed to income differences across countries. However, the results are significantly smaller than prior studies on forest preservation in Puerto Rico (Tavárez and Elbakidze 2021). The proposed project requires human intervention in the forest ecosystem to establish and maintain the nursery as opposed to forest preservation programs that limit interventions in the forest. Some respondents in our study may have discounted the value of forest alterations from interventions, which may affect other ecosystem services provided by the forest.

We estimated two additional models to examine robustness of the results and WTP estimates with corresponding confidence intervals (results not shown but available upon request). The first model includes multiple dummy codes for all categorical variables, and the second model uses mid-points for the income and access variables. For the first model, only one level of the income variable is significant, and in the second model, the variables for midpoints are insignificant. According to the Akaike Information Criterion, Schwarz Criterion and Adjusted Pseudo-R Squared,

Table 4 Willingness to pay estimates across regression models

Regression models	Willingness to pay ($)	95% Confidence intervals[a]
Model 1	43.99	32.12–57.57
Model 2	42.66	32.07–54.61
Model 3	42.88	32.49–55.35

[a]Confidence intervals are calculated following the Krinsky and Robb procedure (1986)

which penalize the inclusion of a high number of parameters included in the model, these two models do not provide improved model fit. Furthermore, the WTP estimates and confidence intervals remain relatively unchanged.

The *t*-tests results suggest that residents involved in environmental management initiatives are younger (mean = 55.53, SD = 1.55) than uninvolved residents (mean = 65.39, SD = 1.24; $P < 0.01$). This result is consistent with the growth in formal and informal environmental education in recent decades. The results also suggest that residents involved in environmental management initiatives are marginally more educated (mean = 3.58, SD = 0.08) than residents not involved in such initiatives (mean = 3.11, SD = 0.07; $P < 0.01$). Educated residents are likely to possess a deeper understanding of the multifaceted contributions that forests make to society, including carbon sequestration and water purification. As a result, they are more inclined to demonstrate heightened interest and engagement in environmental initiatives compared to less educated individuals. This correlation between education and environmental awareness suggests that promoting educational opportunities can be useful for cultivating a broader understanding of the value of forests and for nurturing a commitment to environmental conservation.

The estimated WTP values can be used to compare overall costs and benefits of growing native plants and trees in the RHCM nursery and transplanting them to other forests in the area. The Rio Hondo ward of Mayagüez includes 3047 residents and 1172 households (2.6 persons per household; US Census 2021). Seventy-four percent of respondents in this study were willing to pay for the biodiversity project. By extrapolating these figures, 867 of households are willing to pay for the project. Therefore, the benefits for the region's population over a period of 5 years at 6% discount rate is $166,000. It is important to note that this estimate is based on the assumption that the decisions of some of the residents to not participate in the survey are unrelated to the topic of the survey. Thirty-seven individuals declined to talk to the interviewers. We assume that they refused to engage with the interviewers for reasons such as safety rather than biodiversity preferences. Safety could have been a concern for some of the residents as the timing of the interview overlapped with heightened crime occurences in the region and COVID19.

We obtained costs of establishing and maintaining the nursery and transplanting the trees from two private firms in the western Puerto Rico with experience in nursery development. The costs were estimated at $95,000 over a period of 5 years at 6% discount rate. Thus, projected benefits are 75% higher than the costs of the biodiversity project, indicating that the project is economically viable. However, the costs ($39,150) are greater than the benefits ($37,281) in the first year of the project.

While the objective of this study focused on eliciting WTP for improving biodiversity via plant and tree planting in the local forest, the focus group participants also expressed interest in using the forest for economic growth including employment opportunities and income from tourism and commercialization of local products. We do not address these benefits explicitly in this study. Instead, we quantify WTP for biodiversity improvement program. The estimated WTP may include the perceived values of potential pecuniary benefits from improved forest biodiversity.

Conclusions

Forests play a vital role in enhancing the quality of life in the surrounding communities by offering a wide array of goods and services, including carbon sequestration, air purification, and recreational opportunities. To support biodiversity and ensure forest sustainability, nurseries for native plants and trees can be an effective tool. However, establishing and maintaining such projects can be costly. As a result, such projects are unlikely to be pursued without first documenting that potential benefits can outweigh the costs.

The benefits of such programs depend on the preferences of local residents. Environmental involvement and education play significant roles in shaping these preferences and promoting biodiversity and conservation initiatives. In this study, we used a contingent valuation method to estimate households' WTP for increasing biodiversity through the enrichment planting of native plants and trees sourced from a local forest nursery. Additionally, we assessed the influence of environmental awareness on residents' support for the biodiversity project.

The results show that households in the Rio Hondo ward (Puerto Rico) are willing to pay $43/year to enhance the RHCF biodiversity through establishing a nursery for native plants and trees and transplanting them throughout the forest. These WTP estimates are considerably smaller than estimates of WTP for forest preservation in Puerto Rico (Tavárez and Elbakidze 2021). However, the scope of our study is more narrowly focused on biodiversity as opposed to forest conservation broadly. Therefore, a lower WTP in this study can be expected. Another reason for a lower WTP in this study can be that the proposed biodiversity project in the RHCF requires human intervention to establish and maintain the nursery. Some respondents may have viewed this as contrary to preservation initiatives that restrict human interventions. Such respondents may have discounted the value of nursery-based biodiversity support strategy.

Tavarez and Elbakidze (2021) evaluated the effect of environmental dispositions on urban forest valuation. We contribute to their research by exploring three elements of environmental disposition to evaluate resident preferences

for increasing biodiversity. In particular, we consider prior work experience or education in environmental conservation-related agencies, current involvement in environmental organizations, and willingness to volunteer in environmental sustainability projects. We found that willingness to volunteer in forest management and overall environmental awareness (engagement in at least one of the three elements) are correlated with willingness to support biodiversity using native plants and trees from a nursery. Additionally, we found that age and education are not correlated with WTP for the nursery-based biodiversity program but are correlated with environmental awareness. This suggests that to encourage forest management, policy makers can use education and outreach activities to grow environmental awareness.

This study used data collected from 208 survey participants. Although prior studies have conducted contingent valuation studies with fewer observations (Kotchen and Reiling 2000; Christie et al. 2006; Akram and Olmstead 2011), this figure may be considered relatively low. Additional studies may be needed to extend our results to a larger sample and geographic region.

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Author contribution HT and OA contributed to the conception and design of the study. Data analysis was performed by HT and LE. The first draft of the manuscript was written by HT and OA and revised by LE. All authors have read and approved the final manuscript.

Data availability The dataset used for this study is available upon request to the corresponding author.

Declarations

Ethics approval This study was approved by the Institutional Review Board on Human Subjects (no. 2021040026) of the University of Puerto Rico at Mayagüez in April 2021.

Competing interests The authors declare no competing interests.

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