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AN INSIGHT INTO THE ECONOMIC VALUE OF REEF ENVIRONMENTS THROUGH THE LITERATURE: THE CASE OF THE SEAFLOWER BIOSPHERE RESERVE

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ABSTRACT

The Seaflower Biosphere Reserve (SBR) is one of the few places in Colombia with a set of available studies on the economic value of its reef environments. This paper seeks to review the policy applications of these studies, and evaluate the use of benefit transfer (BT) methods to predict value estimates for sites in the SBR where no valuations have been performed. First, the paper provides an analysis and categorization of policy uses of existing results. A set of economic valuation studies were identified as somewhat influential in policy applications, because they provided financial sustainability tools for marine protected areas. A case study was selected from the pool of influential studies in order to assess the viability of BT. Second, the viability of using BT for determining recreational values of coral reefs within the SBR was assessed by: i) implementing a demand function transfer between the Johnny Cay Regional Park and the Old Providence and McBean Lagoon National Park; and ii) by estimating a meta-analytic function transfer based on world-wide meta-data on the recreational value of coral reefs. Results suggested a potential for the use of BT to predict recreational values for coral reefs in the SBR. In particular, the meta-analytic results indicated low to moderate transfer errors for the SBR, suggesting the viability of this approach.

KEY WORDS: Archipelago of San Andrés, Old Providence and Santa Catalina, Economic valuation, Benefit transfer, Coral reefs, Decision-making.

RESUMEN

Una perspectiva del valor económico de los ambientes coralinos a través de la literatura: el caso de la Reserva de Biosfera Seaflower. La Reserva de Biosfera Seaflower (RBS) es uno de los pocos sitios en Colombia que cuenta con un conjunto de estudios disponibles en valoración económica de ambientes coralinos. Este artículo busca revisar las aplicaciones de política de tales estudios y evaluar el uso de métodos de transferencia de beneficios (BT) para predecir estimaciones de valor en sitios de la RBS donde no se han desarrollado valoraciones. Primero, el artículo provee un análisis y categorización de usos de política de los estudios existentes; se identificó un conjunto de estudios de valoración económica con influencia potencial en aplicaciones de política mediante la provisión de herramientas de sostenibilidad financiera para Áreas Marinas Protegidas. Seguidamente, se seleccionó un estudio de caso del conjunto de estudios con potencial de influenciar la toma de decisiones con el fin de evaluar la viabilidad de BT, mediante: i) la implementación de una función de transferencia de valor entre el Parque Regional Johnny Cay y el Parque Nacional Old Providence y McBean Lagoon; y ii) a través de la estimación de una función de transferencia meta-analítica con base en meta-datos mundiales sobre el valor recreacional de los arrecifes coralinos. Los resultados sugieren el uso potencial de BT como una nueva aplicación basada en los estudios existentes en la RBS. En particular, los resultados meta-analíticos indican errores de transferencia bajos y moderados para la RBS, sugiriendo la viabilidad de esta aproximación.

PALABRAS CLAVES: Archipiélago de San Andrés, Providencia y Santa Catalina, Valoración económica, Transferencia de beneficios, Arrecifes coralinos, Toma de decisiones.

INTRODUCTION

The Seaflower Biosphere Reserve (SBR) is located in the Archipelago of San Andrés, Old Providence and Santa Catalina, Colombia (Figure 1), in the western Caribbean Sea. It encompasses coastal and marine resources, including coral reef structures. One of them, the Old Providence barrier reef, is one of the largest coral reefs in the Americas, with a length of 32 km and an area of 255 km^2 (Unesco, 2011). It was designated a Unesco Biosphere Reserve in 2000, in order to promote sustainable development and alleviate problems associated with overpopulation, environmental degradation and poverty. The islands in the Archipelago are small, with high population density, which ranges from 283 inhabitants/km^2 in Old Providence to 2595 inhabitants/km^2 in San Andrés in 2013 (DANE, 2013a; Gobernación del Archipiélago, 2013). Similar to many coastal areas around the world, the economy of these islands relies heavily on marine resources as sources of income and employment, particularly from tourism, commercial shipping, and fisheries. In 2012, 49% of the added value of the Archipelago's economy was derived from tourism, trade and fisheries (DANE, 2013b). However, these benefits are not without cost. Internationally, there is a concern about the growing conflicts between outdoor recreational tourism and conservation (Shrestha and Loomis, 2001). This also applies to the SBR; James (2008) reported the environmental degradation in Johnny Cay Regional Park (JCRP) (Figure 2) as partially related to the high number of visitors and the anchoring of boats.

Attempts to achieve the multidimensional goals implicit in the SBR designation have been traditionally supported by scientific and technical research, mostly on biophysical aspects. More recently, these endeavors are also being supported by the emergent view of interconnectedness between environmental problems and social wellbeing. Under this perspective, economic valuation can play a key role in understanding environmental problems and improving management policies (Daily *et al*., 2009; TEEB, 2009). In the SBR, the use of non-market valuation is relatively recent. The first application can be traced to the late 90s with a study from Morales (1998) on the aesthetic value of Old Providence Island (Figure 2); since then an increase in the number of valuations has been observed for the SBR. However, challenges persist with regards to the use of valuation estimates to guide policymaking. A better understanding of the policy applications of existing results in the literature is necessary, before new studies are proposed. Conducting new valuations is expensive and demanding in terms of technical capabilities. In this case, benefit transfer (BT) is proposed as an alternative (Shrestha and Loomis, 2001). BT is defined as the transfer of a value estimate from a study site to a policy site where an estimate is not available (Johnston and Rosenberger, 2010).

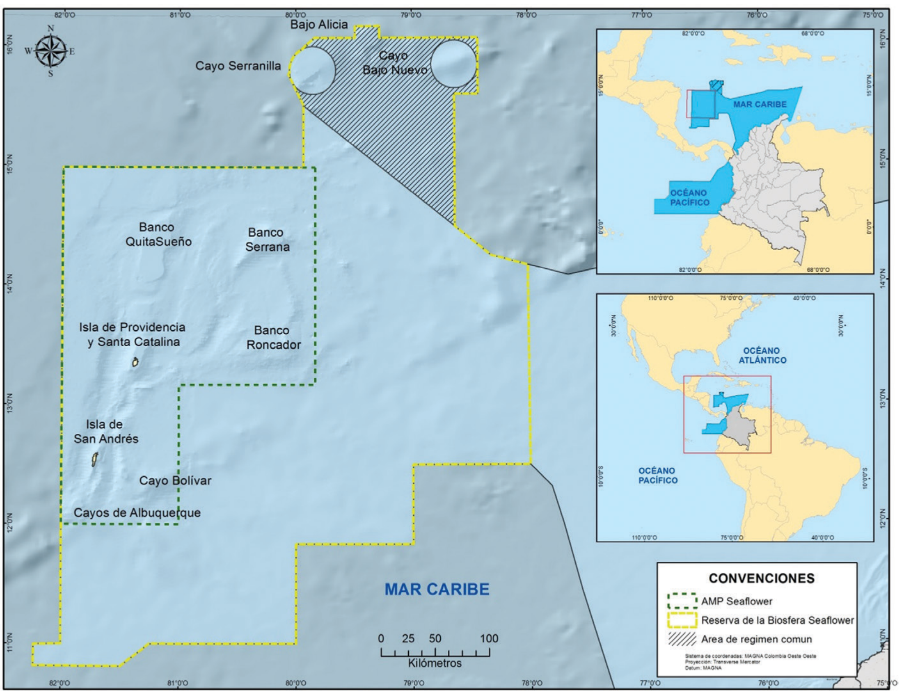

Figure 1. Map of the Seaflower Biosphere Reserve. Source: INVEMAR- Laboratorio de Sistemas de Información (2015)

Figure 2. Map of the San Andrés, Providencia and Santa Catalina Island. Source: INVEMAR- Laboratorio de Sistemas de Información (2015)

With this in mind, the contribution of this paper is to first identify what has been valued in the SBR and provide insights into policy uses of the existing valuation results. Secondly, we seek to explore the prospect of BT as a new policy use in the SBR through demand function transfer (DFT) and meta-analysis (MA). The demand function is tailored to transfer a value estimate from JCRP to the Old Providence and McBean Lagoon National Park (OPNP) (Figure 2), where such results are not available. The meta-analytic BT is implemented by adapting a function based on several study sites from around the world, to predict a value estimate for the SBR.

The organization of this article is as follows. Section 2 provides the methodological approach. Section 3 shows results in terms of a qualitative analysis of the empirical literature on economic valuation in the SBR and quantitative results for both demand function transfer and meta-analytic BT. Section 4 provides a discussion of the results in policy contexts. Finally, section 5 presents conclusions and recommendations for further studies.

MATERIALS AND METHODS

Data used in this article come from secondary sources. With the exception of James (2008), all the studies reported in Table 1 correspond to grey literature, primarily theses. As the first methodological procedure, a qualitative review of studies on economic valuation of coral reef environments in the SBR was performed. Each study source was analyzed considering the following three factors: i) valuation object (commodity and type of value), ii) methodology and iii) uses in policy contexts. This discussion follows the categories of policy applications provided by Billé *et al*. (2012). In addition, these studies were evaluated in terms of the information they provided for the purposes of BT. James (2003) was selected as a case study, as it defined a specific commodity valued at a specific site within the SBR, and included a full definitions of methods, variables and functions. Other studies simultaneously valued a broader set of commodities or studied geographically more extended areas (*e.g*. the entire archipelago).

Next, a quantitative approach to the literature review was used by implementing both DFT and meta-analytic BT. Specifics of both methods are presented in the next two sections. All monetary variables were expressed in constant prices from the year 2000, by using the country-specific consumer price index (CPI) with 2000 as base year (United Nations, 2009). For cases where the original sample was applied to United States (US) visitors or foreigners, the US CPI was used. Finally, all values were expressed in international dollars by using the Purchasing Power Parity (PPP) exchange rate for the year 2000 (United Nations, 2009).

Table 1. Studies providing non-market valuations for coral reef environments in the Seaflower Biosphere Reserve. Note: CV: Contingent Valuation, TC: Travel Cost, MPA: Marine Protected Area. * The authors of this article did not have access to this study, therefore its results will not be analyzed here.

Author	Valuation object		Methods	Potential policy applications
	Commodity	Type of value		
Carrera (2008)	Coral reef conservation programs for MPA.	Direct and indirect use and non-use values, including cultural values.	CV, open-ended elicitation question.	Informative use, environmental awareness and advocacy.
Morales (1998)	Scenic natural landscape of Old Providence.	Direct use value: aesthetic and indirect: conservation values.	CV, dichotomous choice elicitation question.	Informative use, Environmental awareness and advocacy.
Cheng *et al.* (2003)*	Recreational value of a MPA.	Direct use value.	CV, not available.	Not available
James(2003)	Recreational value of a MPA.	Direct use value.	TC, random utility model.	Technical result to support the design of a price instrument to regulate access to a MPA and potentially BT
James (2008)	Recreational value of a MPA.	Direct use value.	CV, dichotomous choice, open-ended elicitation question.	Technical result to support the design of a price instrument to regulate access to a MPA and potentially BT.
Castaño (2010)	Coastal protection of beaches in link to recreational uses.	Direct and indirect use value.	CV, dichotomous choice elicitation question; lost revenue.	Criterion for environmental management, supporting targeted conservation efforts for beach regeneration in link to coral reef services.
Newball (2001)	Coral reef conservation through the establishment of an MPA.	Direct and indirect use and non-use values.	CV, dichotomous choice elicitation question.	Informative, justification and support for the establishment of an MPA.

Function transfer: demand function

The DFT uses information provided by James (2003) as a case study to evaluate the viability of BT. James (2003) sought to estimate the demand for recreation at JCRP and an entrance fee as tools to support self-financing and conservation. Under the assumption of potential similarities between attributes and visitors at JCRP and OPNP, the adaptation of James (2003) demand function allows the possibility of predicting entrance fees for other regional parks in the SBR, as a new potential policy application. In this article, this process was carried out by using the estimated model from James (2003) and sample data from visitors to OPNP. A single demand function is used, under the assumption of consistent similarities between the study site (JCRP) and policy site (OPNP). The demand function for recreation at JCRP by tourists visiting San Andrés was tailored to predict a value estimate for OPNP, where such results are not available.

By using the contingent valuation (CV) method with a dichotomous choice elicitation format, James (2003) modeled the willingness to pay (WTP) as the logistic probability function below, which seeks to measure the probability of a positive answer to the WTP question. It is expressed in terms of an elicited price, country of origin, sex, age, education and employer of respondents (Table 2):

Table 2. Variables in demand function transfer and corresponding descriptive statistics. Source: James (2003) and authors calculations.

Variable	Description	Mean	Std. Dev.
Price	Reported price in PPP US$ (2000).	6.5	5.1
Country	Dummy variable for country origin: takes the value of one when it is from Colombia, zero otherwise.	0.81	-
Sex	Dummy variable for male or female survey respondent: takes the value of one when it is male, zero otherwise.	0.57	-
Age	Age reported by respondents.	37	11.1
Education	Categorical variable: takes the values [1-5] depending on the case (no education, primary education, secondary education, college education, postgraduate education).	3,84	-
Employment	Dummy variable for type of employer: takes the value of one when the respondent is employed, zero otherwise. Students, housewifes and pensioners are considered unemployed.	0.81	-

$$Probability(yes) = \frac{1}{1 + e^{\beta_0 - \beta_1 price + \beta_2 country + \beta_3 sex + \beta_4 age + \beta_5 education + \beta_6 employer}}$$

After plugging the parameters estimated by James (2003) into the above equation, the equation below is obtained. Note that only the variables of price (elicited WTP as an entrance fee to JCRP), country of origin, education and type of employer of respondents remain in the equation due to their statistical significance (price and country significant at 1%, education at 5%, and employer at 10%).

$$Probability(yes) = \frac{1}{1 + e^{1.1956 - 0.0002\ price - 2.5791\ country - 0.9452\ employer}}$$

In order to transfer benefits from JCRP to OPNP, the sample mean of the independent variables measured for tourists in Old Providence and Santa Catalina (Parque Nacional Natural Old Providence McBean Lagoon, 2012) were used to calculate price using the above equation.

Function transfer: Meta-analysis

The meta-analytic BT used meta-data from Londoño and Johnston (2012), which pools together existing CV and TC studies on the recreational value of coral reefs from sites around the world. For the purpose of the analysis presented here, only CV studies from the original meta-data were selected, in order to maintain consistency of the welfare measure (Bergstrom and Taylor, 2006). The meta-data was supplemented with one observation for the SBR. The study sources include 24 original valuation studies taken from journal articles, theses, dissertations and technical reports, including one study from the SBR, namely James (2003, 2008). The list of studies in the meta-data is presented in Table 3. These studies yield a total of 71 observations (some studies provided more than one observation). Table 4 summarizes the meta-data in terms of the full set of covariates and the dependent variable, taking into account the form (linear or natural log) in which they enter the meta-regression model (MRM). Here, the WTP for a day of recreation, as a dependent variable, is hypothesized to be determined by attributes identified in the extant literature on coral reef valuation (Brander *et al*., 2007; Londoño and Johnston, 2012).

Following standard procedures in the literature, the meta-analytic component was developed by implementing a multilevel model (Bateman and Jones, 2003). This corrects for cross-sectional correlation between observations from the same level (*e.g.* several observations from the same study), and generates more accurate measures of standard errors and significance of parameters (Goldstein, 1995; Bateman and Jones, 2003; Johnston *et al*., 2006). Each observation *i* in the meta-data is expressed through the mean WTP from study *s*. This is denoted by $\bar{y}_{is}$,which is explained by a vector of variables $\bar{x}_{is}$, representing the set of attributes determining the welfare measure (methodological aspects, site and population attributes), the vector of model parameters β and the error term ε_{is}. The effect size in the meta-regression model is denoted by:

$$\bar{y}_{is} = \bar{x}_{is}\beta + \varepsilon_{is}$$

The error term ε_{is} is partitioned into two components (variance components model), each one corresponding to one level in the hierarchy of the meta-data: the study level (s) and the observation level (i):

$$\varepsilon_{is} = u_s + e_{is},$$

Where u_s is the study-level random effect, which is normally distributed with E (u_s) = 0 and Var (u_s) = $\sigma^2 u$ and e_{is} is an estimation level error, distributed with a zero mean and constant variance $\sigma^2 e$ (Shrestha and Loomis, 2001). The meta-regression was estimated by using a random effects model with robust standard errors (Nelson and Kennedy, 2009).

The hypothesis of transferability was tested using an in-sample validity test, where the estimated meta-parameters are used to predict values for each observation in the sample. Here the null hypothesis implies that the difference between the meta-predicted values and the original values is zero. A t-test, as is illustrated by Shrestha and Loomis (2001), was performed.

Table 3. Studies in the meta-data. Sources: James (2003) and Londoño and Johnston (2012).

Author and Year	Title	Site	Obs.	Type of Publication	WTP (2000 US$ person/ day, adjusted for PPP)
Ahmed *et al.* (2007)	Valuing recreational and conservation benefits of coral reefs—The case of Bolinao, Philippines	Bolinao, Philippines	2	Journal article	0.5
Andersson (2007)	The recreational cost of coral bleaching — A stated and revealed preference study of international tourists	Zanzibar, Mafia, Tanzania	6	Journal article	49.7 - 117.4
Arin and Kramer (2002)	Divers' willingness to pay to visit marine sanctuaries: An exploratory study	Anilao, Philippine	3	Journal article	3.6 - 9.8
Asafu-Adjaye and Tapsuwan (2008)	A contingent valuation study of scuba diving benefits: Case study in Mu Ko Similan Marine National Park, Thailand	Mu Ko Similan Marine National Park, Thailand	2	Journal article	24.8 - 62.6
BAPPENAS (1996)	Recreation values of tourists for Bunaken National Marine Park, North Sulawesi	Bunaken National Marine Park, North Sulawesi, Indonesia	3	Report	2.1 - 13.5
Cesar and van Beukering (2002)	Economic valuation of the coral reefs of Hawaii	Hanauma Bay, Hawaii and Hawaii, USA	4	Journal article/Report	8.6 - 10.3
Chi-Ok *et al.* (2008)	The economic value of scuba-diving use of natural and artificial reef habitats.	Flower Bank, US.	2	Journal	18.1 - 30.6
Díaz (2001)	Hallando la tarifa de entrada óptima al Parque Corales del Rosario: un modelo de disponibilidad a pagar	Parque Nacional Natural Corales del Rosario y San Bernardo, Colombia	1	Ms Thesis	6.8
Dixon and Scura (1993)	Meeting ecological and economic goals: The case of marine parks in the Caribbean	Bonaire, Netherland Antilles	1	Report	5.8
Hundloe (1990)	Measuring the value of the Great Barrier Reef	The Great Barrier, Australia	2	Journal Article/report	9 - 14.8
James (2003)	Estimación de la tarifa de acceso al Parque Regional Johnny Cay (San Andrés)	San Andrés Island, Colombia	1	Ms Thesis	7.59
Johns *et al.* (2001)	Socioeconomic study of reefs in southeast Florida	Southeast Florida, USA	16	Report	2.7 - 27
Mathieu (2003)	Valuing marine parks in a developing country: a case study of the Seychelles	Seychelles	1	Journal article	13.1

Continuation, Table 3.

Author and Year	Title	Site	Obs.	Type of Publication	WTP (2000 US$ person/ day, adjusted for PPP)
Mohamed (2007)	Economic valuation of coral reef: A case study of the cost and benefits of improved management of Dhigali Haa, a Marine Protected Area in Baa Atoll, Maldives	Baa Atoll, Maldives	4	M. Sc. Thesis	11.8 - 33.5
Nam and Son (2001)	Analysis of the recreational value of the coral-surrounded Hon Mun Islands in Vietnam	Hon Mun Islands, Vietnam	2	Report	15.3-19.3
Ngazy *et al.* (2004)	Coral bleaching and the demand for coral reefs: A marine recreation case in Zanzibar	Unguja (Zanzibar), Tanzania	1	Report	7.5
Park *et al.* (2002)	Valuing snorkeling visits to the Florida Keys with stated and revealed preference models	Florida Keys, USA	2	Journal article	43.7
Thur (2003)	Valuing recreational benefits in coral reef marine protected areas: An application to the Bonaire National Marine Park.	Bonaire, Netherland Antilles	2	Ph. D. Dissertation / Journal article	10.1 - 19.8
Rivera-Planter and Muñoz-Piña (2005)	Tarifas y arrecifes: instrumentos económicos para las áreas protegidas marinas en México.	Cancun-Nizu, Isla Contoy, Cozumel, Puerto Morelos, México	4	Journal article/Report	2.1 - 6.9
Rosales (2003)	A survey to estimate the recreational value of selected MPA's: Moalboal-Cebu, Siquijor and Pamilacan Island-Bohol	Moalboal-Cebu, Siquijor and Pamilacan Island-Bohol, Philippines	3	Report	4.1 - 27.8
Seenprachawong (2003)	Economic valuation of coral reefs at Phi Phi Islands, Thailand	Phi Phi Islands, Thailand	4	Journal article	3.6 - 8.9
White *et al.* (1997)	Using integrated coastal management and economics to conserve coastal tourism resources in Sri Lanka	Hikkaduwa, Sri Lanka	3	Journal article	7.5 - 10.4
Wright (1995)	An economic analysis of coral reef protection in Negril, Jamaica	Negril, Jamaica	8	College Senior Thesis	5.3 - 14.2
Yeo (2004)	The recreational benefits of coral reefs: A case study of Pulau Payar Marine Park, Kedah, Malaysia	Pulau Payar Marine Park, Kedah, Malaysia	2	Book chapter	4.6 - 4.9

Table 4. Variables in the meta-data and corresponding descriptive statistics.* This variable was included to test the hypothesis of a positively significant relationship between WTP and location of reefs in East Africa (as pointed out in the empirical literature by Brander *et al*., 2007).

Variable	Description	Mean	Std. Dev.
WTP	Willingness to pay person/day in PPP US$ (2000), expressed in natural log.	15.01	19.22
Dichotomous Choice	Dummy variable for elicitation method: takes the value of one when it is dichotomous choice, zero otherwise.	0.17	0.38
Payment card	Dummy variable for elicitation method: takes the value of one when it is payment card, zero otherwise.	0.45	0.50
Trip expenditure	Dummy variable for payment vehicle: takes the value of one when additional trip expenditures are used, zero otherwise.	0.38	0.49
Donation	Dummy variable for payment vehicle: takes the value of one when it is a donation, zero otherwise.	0.15	0.36
Sample size	Scalar variable for sample size expressed in natural log.	5.17	1.25
Onsite survey	Dummy variable for the sampling method: takes the value of one when it is onsite sampling, zero otherwise.	0.56	0.50
Publication type	Dummy variable for the type of publication: takes the value of one when it is a published article, zero otherwise.	0.41	0.50
Region	Dummy variable for region: takes the value of one when it is East Africa, zero otherwise.*	0.08	0.28
Area	Scalar variable for the size of the MPA expressed in natural log.	5.25	3.57
MPA	Dummy variable for existence of a protection category: takes the value of one when it is a marine protected area, zero otherwise.	0.86	0.35
Snorkeling/Diving	Dummy variable for recreational activities: takes the value of one when the study is focused on snorkeling and diving, zero otherwise (fishing, viewing and others).	0.28	0.45
Live coral cover	Percentage of live coral cover reported during the year corresponding to the study or within a one year difference.	0.30	0.25
Reef type	Dummy variable for type of reefs: takes the value of one when it is a natural reef, zero if it is artificial.	0.87	0.34

RESULTS

The use of valuation results in policy contexts in SBR

In order to respond to the initial objective of identifying what has been valued and what insights can be gained in terms of policy uses, this section starts by analyzing valuation results in the SBR. Most of the non-market valuation studies in the SBR include recreational values of coral reefs; some of them have sought to provide value estimates that could be used to improve conservation management of coral reef services. This trend is also observed in other economic valuation studies in Colombia (Rueda *et al.*, 2011) and around the world (Londoño-Díaz, 2010).

To the knowledge of the authors, the extant literature on non-market economic valuation applied to coral reef environments in the SBR consist of six studies, which are summarized in Table 1 in terms of: i) the valuation object, identifying both the commodity being valued and the type of value, ii) implemented valuation methods, and iii) potential policy applications from such studies. While factors i and ii are presented for basic characterization purposes, factor iii is key to the discussion of this section.

Following Laurans *et al*. (2013), studies in Table 1 are classified in terms of three main categories of use in policy contexts: decisive, technical, and informative. The first category refers to decisive valuations for specific decisions, implying cases in which *ex-ante* information on values is provided to the decision maker. Then, valuation results are used to facilitate a choice between alternatives, through tools such as benefit-cost analysis (BCA) that incorporates environmental value estimates. Newball (2001) is part of this category. From a policy perspective, results from this work supported the establishment of a MPA (Figure 1) scheme in San Andrés (established in 2005) by justifying the financial and economic rationality of the chosen protection scheme over a 20 year period. Castaño (2010) could also be placed into this category; however, it does not include a BCA. This study suggests opportunities for payments for ecosystem services (PES), based on beach management, considering the importance of this ecosystem in the financial sustainability of the SBR. Towards this purpose, the study linked beach regeneration to specific coral reef services, identifying territories to allocate conservation efforts and laying out beach management scenarios. A potential policy use from this study might involve an implementation of tourist payments for the entire SBR, pledging the resulting revenue to the maintenance of key coral reef services, conservation of organisms and beach management.

The second category, technical ecosystem services valuation, involves studies where an economic instrument is proposed after the policy has been selected. The aim of the valuation study in this case is the adjustment of an economic instrument. James (2003) falls into this category in the SBR. This work provided detailed information on the estimation of the recreational value of coral reefs in JCRP by using two different methods, CV and TC, which were applied to the tourist and local populations, respectively. In terms of policy applications, these results provided a basis for a technical design of entrance fees to the JCRP. In this case, the environmental authority had already established a recreational use for this regional park and decided to use a price instrument, perhaps in order to reach goals for financing the cost of conservation and reducing the environmental pressure from visitors. This study also provides a replicable model for BT purposes for regional parks within the SBR, as the viability of BT requires the existence of sites with similar attributes and the provision of sufficient methodological information (methods, variables and functions).

Finally, the third category corresponds to informative ecosystem services valuation to support decision making from a more broad perspective. This category relates to studies that shed light on plausible environmental policies, rather than establishing a specific alternative. Morales (1998) and Carrera (2008) provided informative results on societal preferences for environmental services. In the first case, the author sought to raise environmental awareness about landscape conservation in Old Providence. Environmental advocacy based on valuation results from this study could work to influence public policy to curb habitat transformation in Old Providence. In the second case, the author elicited the value of a coral reef conservation program in San Andrés. Findings from this study, in terms of policy options, support household participation in payments for programs to establish cultural and natural conservation mechanisms under MPA structures. Both of these studies point to monetary value estimates as a way to advocate for conservation, by informing the decision process with social preferences on ecosystem services.

Benefit transfer

Function transfer: demand function

After adapting the benefit function illustrated in the methodological section to OPNP as a policy site, the model forecasts an entrance fee of \$6.5 per person. This value is higher than the weighted average of the actual entrance fee charged in 2011 (\$5.1). This suggest that an entrance fee based on the results from the demand function transfer provided here could represent an increase of about 30% in total revenues for OPNP compared to the revenue based on the entrance fee charged in 2011. James (2003) does not report the standard error for of the original estimated entrance fee; this hinders the computation of a confidence interval for the adapted measure provided here.

Note also that the forecasted value is exclusively determined by socio-demographic variables in Table 2, therefore the model does not allow controlling for site differences such as the environmental quality of the local ecosystems. The MRM presented in the next section addresses that issue by incorporating coral reef cover and type of reefs as covariates within the model.

Function transfer: Meta-analysis

Results from the MRM are presented considering two aspects: i) interpretation of value surfaces with regards to theoretical expectations and statistical significance of covariates, and ii) the potential for valid meta-analytic BT. In the first case, consider the results in Table 5, which contains the statistical results of the estimated MRM. As the model was specified through a trans-log form, the coefficients in Table 5 correspond to the constant relative change in the dependent variable for a given absolute change in the value of the independent variable. Note that 6 out of the 13 covariates and the coefficient in the model are statistically significant for certain values of the dependent variable. These include four methodological covariates. Both Dichotomous choice and Payment card seem to have negative and significant relationships with WTP values, these variables are statistically are significant at $p < 0.10$ and at $p < 0.05$ respectively. These covariates, as elicitation methods, have shown similar results in the empirical literature (Rosenberg and Loomis, 2000; Stapler, 2006). Trip expenditures, as a payment vehicle, is significant at $p < 0.05$. This covariate, as a voluntary payment vehicle, seems to keep a positive relation with the welfare measure when compared to non-voluntary payment vehicles (*e.g.* entrance fees) (Brouwer *et al*., 1999; Campos *et al*., 2007; Lindhjem and Navrud, 2008). Finally, the result for Sample size suggests that observations taken from studies with larger sample sizes can result in significantly higher measures of welfare estimates ($p < 0.01$).

With regard to site characteristics, Table 5 indicates positive and statistically significant relationships between the welfare measure and the covariates live coral reef cover and type of reefs. The sign of these parameters is also consistent with anticipated results. However, there is no prior reference in the meta-analytic literature with respect to the significance of these covariates. The empirical evidence on the positive connection between reef quality and welfare measures has only been documented by primary studies (Parsons and Thur, 2008; Wielgus *et al*., 2009).

Meta-analytic benefit transfer functions (MBTF) were constructed by using the estimated parameters presented in Table 5. MBTF were used in the computation of predictive values, which were subsequently used to calculate transfer errors (TE) for each observation in the sample (sites). This error is measured as the difference between the meta-predicted value and original estimate, expressed as a percentage. Average transfer errors (ATE) were also computed in order to assess the hypothesis of transferability based on the complete set of meta-data.

Results from the in-sample validity test indicated lower ATE compared to the results in the literature (Brander *et al*., 2007; Londoño and Johnston, 2012). Further research to compute out-of-sample validity testing is recommended for a closer comparison of these results to those in Brander *et al*. (2007) and Londoño and Johnston (2012), and when weighing the pros and cons of using MBTF for a specific policy purpose. Table 6 presents the ATE calculated from the meta-data and also the calculated TE for the SBR. As a comparative reference, Table 6 also presents the computed TE for Bonaire based on the same meta-data.

The hypothesis test of statistical equivalence of predicted and observed values was conducted through a paired t-test. This indicates that the two sets of WTP values

Table 5. Meta-regression results for ln WTP (natural logarithm of willingness to pay) as dependent variable. Source: Author's calculations based on classical meta-regression. Note: *p < 0.10, **p < 0.05, ***p < 0.01. STATA Version 11 used. R2 comes from a supplementary ordinary least square (OLS). estimation with robust standard errors, estimated only as a reference.

Independent variables	Coefficient	Robust standard error
Dichotomous choice	-0.611093	0.317854*
Payment card	-0.790743	0.359461**
Trip expenditures	0.797848	0.382441**
Donation	0.390523	0.493885
Sample size	0.261560	0.092628**
Onsite survey	-0.273252	0.303856
Publication type	0.442812	0.327682
Region	-0.216975	0.640677
Area	-0.005982	0.038535
MPA	0.879509	0.730236
Snorkeling/Diving	0.144625	0.357414
Live coral cover	2.071788	0.533669***
Type of reefs	0.578349	0.329080*
Constant	1.056319	0.442232**
N	71	
Panels (studies)	24	
-2loglikelihood	-132.24	
R2	0.49	

are statistically different, implying that the TEs are statistically different from zero, which discourages the use of meta-analytic BT. Other studies conducting similar tests in different locations around the world, for both domestic and international BT, had similar findings (Shrestha and Loomis, 2001, 2003; Rosenberger and Stanley, 2006; Lindhjem and Navrud, 2008). Nevertheless, the conclusion is not straightforward for the SBR, where the individual TE for JCRP (4.5%) is smaller than the ATE (57.4%)

Table 6. Average transfer error and transfer errors for selected cases. Source: Author's calculations.

Study (site)	Meta-predicted values (WTP 2000 US$ person/day, adjusted for PPP) and 95% confidence interval (CI)	Transfer error
All sites	12.24 (CI: $9.13-15.35)	57.4%
James (2003) (JCRP-SBR, Colombia)	7.25 (CI: not available in original study)	4.5%
Thur (2001) (Bonaire Marine Park, Bonaire, The Netherlands)	9.31-11.19 (CI: not available in original study)	7.96- 43.48%

as shown in Table 6. According to Kristofersson and Navrud (2005), reliable TEs for policy applications only need to be relatively small. Moreover, Kristofersson and Navrud (2007) suggest that a TE lower than 40% can be reliable, depending on the political application (Lindhjem and Navrud, 2008).

DISCUSSION

Existing valuation studies were analyzed with regards to policy use. But, what can be said about the actual contributions from these studies to policy making and management? The answer to this question can be partially given by the fact that three out of the seven studies in Table 1 (namely: Newball, 2001; James, 2003; Castaño, 2010) were, to some extent, performed with support from the environmental management agency of the SBR, aimed at providing results to inform timely relevant queries. In 2001, the environmental authority of the Archipelago, CORALINA, declared the JCRP. This action was followed by initiatives to conduct studies on carrying capacity of beaches and the establishment of entrance fees. As a response to this request, James (2003) provided a CV study estimating an entrance payment, which was modeled using the socio-demographic characteristics of the tourist population. In this way, the study, along with other available information, came to support the setting of an entrance fee value by the environmental authority. Newball (2001) provided an economic valuation of coral reef conservation in San Andrés, which proposed a financial model to support the implementation of an MPA in the Archipelago. Four years later, in 2005, the Seaflower MPA was declared. More recently, the topic of PES has drawn the interest of practitioners at the Seaflower MPA. As a response to that call, Castaño (2010) proposed financing mechanisms for the Seaflower MPA based on marine and coastal PES. However, the implementation of such PES projects is still in an exploratory phase in Colombia. Therefore actual contributions from this study can only be assessed in terms of the benefits of providing decision makers with *ex-ante* information to support a better choice of policy alternatives in the future.

International reviews on the practical benefits from valuation studies have found modest contributions from such studies. For the south Pacific, researchers found that, in general, the expected outcome for economic valuation studies was to "inform and convince" during the decision process when facing alternatives (Pascal *et al*., 2012). However, a difference with SBR cases remains. Generally, SBR cases do not incorporate economic comparison of alternative policies. This could be attributed to the practice of choosing policies before the economic analysis is performed. It could also be related to the perception of valuation as a tool to support policies selected through expert criteria, rather than economic criteria (*e.g.* efficiency, cost-efficiency, and effectiveness), or by the high cost of more comprehensive economic analyses. Pascal *et al.* (2012) also found that the impact of valuations on policy decisions varied, and was generally lower than expected. The authors hypothesized that such results could be a function of the time span in which results can be actually observed, *i.e.* the period of time could sometimes be too short to accurately quantify the effectiveness of valuation results.

In the Caribbean, a similar review (Kushner *et al*., 2012) also suggested that there was uncertainty on whether valuation efforts had significant impacts on policy making. However, the authors identified cases in which valuations have been influential, and outlined conditions to improve the chances that a study will be successful in influencing policy. Some conditions outlined by Kushner *et al.* (2012), which could be relevant for SBR, include: maintaining strong stakeholder engagement, clearly presenting methods and limitations, identifying opportunities for raising revenue, and effectively communicating with decision makers and/or media.

The case study provided by James (2003) also represents a relatively straightforward approach to evaluate the use of BT as a new policy application in the SBR. For the case of the DFT, results suggest an alternative way to provide a basis for the determination of an entrance fee in OPNP, in the absence of financial or technical resources needed to conduct a primary valuation there. Under the appropriate circumstances, BT results can be used to adjust measures initially determined *ad hoc*, by expert criteria or by single point value transfer (direct value transfer from another site). Demand function transfers outperform (lower error) point estimate transfers, and thus they can represent welfare improvements over point estimates (Rosenberger and Loomis, 2000). BT is, however, only a second best option. Primary valuation studies provide more accurate results, as they are based on the measurement of model parameters for visitors to the actual site, and incorporate site idiosyncrasies. For instance, the estimation of a new original model can be designed to capture site differences (*e.g.* mangrove presence in OPNP vs. JCRP, differences in coral reef cover, among others). BT functions may face limitations when original studies do not provide information on environmental attributes, which is the case for most studies in the SBR. With exception of Castaño (2010), environmental attributes of the study sites are not included in the valuation models for SBR, which provides a rationale for new studies. The lack of environmental attributes in the valuation model affects the capability of the model to respond to policy questions when environmental attributes change.

Meta-analytic BT offers another alternative to primary valuation, and compared to DFT has several advantages: the BT function is based on a large set of studies (rather than a single one), and it allows for the incorporation of site and methodological attributes through the supplementation of original studies with secondary sources. These advantages are illustrated in the results presented by this article. A meta-data based on multiple reef sites from around the world allowed for the estimation of valuation patterns in the existing literature and the confirmation of empirical and theoretical hypotheses on the significant effect of methodological and site attributes on the welfare measure. Moreover, it allowed for the inclusion of environmental quality variables, often ignored in original studies, into the MRM. These results indicated, for the first time in a meta-analytical study, a positively significant relation between WTP and coral reef cover and type. A potential implication in terms of policy options is, for instance, that restoration projects, such as transplanting corals, might yield higher social benefits than building artificial ones. These findings also refute the common perception of coastal tourism as solely determined by preferences for sun, sea and beach. The general pattern, indicated by the MRM, points out that the willingness to pay is significantly higher at sites with a higher percentage of coral reef cover.

With regard to the viability of meta-analytic BT, the literature provides no consensus on acceptable levels of TE. However, it is generally agreed that smaller TEs are necessary when moving from simple BCA to the implementation of compensatory payments (Rosenberger and Johnston, 2009). Table 6 also reports meta-predicted values and 95% confidence intervals. For JCRP the meta-predicted value is \$7.25, which represents the predicted value for an entrance fee paid by a single tourist/day. This result is comparable to others found in the CV literature in the Caribbean (Table 2), such as those in Díaz (2001) and Thur (2003). This meta-analytic result does not differ much from the one predicted by the demand function transfer for JCRP (\$6.5). A higher estimate from the MRM, when compared to the demand function transfer, is associated with the set of explanatory variables used in each case. While the DFT based on James (2003) only uses socio-demographic variables, the MRM includes covariates for site (*e.g.* live coral cover) and methodological (*e.g.* elicitation format) attributes. For this situation, the meta-analytic literature has pointed out the lack of sufficient reporting of site, socio-demographic and methodological variables in primary valuation, which affects the availability of information to conduct MA (Spurgeon, 2001; Brander *et al.*, 2007; Londoño and Johnston, 2012). For instance, the inadequate reporting of socio-demographic variables in most primary valuation studies hindered the inclusion of this set of covariates in the meta-data, and therefore the ability of the meta-regression model to assess their effect on WTP.

Overall, results indicate that valuation studies in the SBR have tended to be more in line with an informative and technical perspective than a decisive one. However this seems to be the case in other regions of the world (Kushner *et al.*, 2012; Pascal *et al.*, 2012). BT is a potential new policy application in the SBR, which is explored here through both DFT and MA. Findings suggest that both could represent alternatives to transfer values for the estimation of entrance fees in marine parks in the SBR. The meta-analytic version provides the additional advantage of considering the quality of the reefs as a covariate within the valuation model, which could be beneficial to assess the effect of environmental changes on estimated values. It also relaxes the assumption of close site similarities implicit in the demand function transfer by tailoring the MRM to the policy site.

CONCLUSIONS

In the SBR, like in other sites in the wider Caribbean and South Pacific regions, the connection between economic valuation results and policy design is a work in progress. The review provided here indicates two cases where studies have been influential to some extent, providing technical information to support decision making on financial sustainability of a MPA (Newball, 2001; James, 2003). The review also identified another study providing a potentially decisive evaluation, which could support the implementation of payments for coral reef services associated with beach regeneration (Castaño, 2010). Two additional cases provided informative valuations, mostly oriented towards advocacy for conservation and the promotion of environmental awareness (Morales, 1998; Carrera, 2008). The review also indicates a lack of studies providing comparative valuations of policy options before a specific policy is chosen. Although this practice is cost-saving in the short term, it can hinder the implementation of more efficient or cost-effective policies in the long term.

A value estimate was generated for OPNP using a predictive DFT, based on James (2003). This constitutes a potential new policy application based on the available studies for the SBR. The meta-analytic approach to BT indicated a low TE for the SBR, suggesting the potential use of this method when new value estimates are required, in the context of changing environmental conditions (for instance, changes in the percentage of live coral cover). However, BT options should be considered as a second best, when primary valuation is not possible.

Both the qualitative and quantitative analyses indicated the need for valuation studies that address specific, relevant policy questions. This process should be conducted with the close involvement of key stakeholders, who are the users of the valuation results. Studies in the SBR should also move beyond the economic valuation of single policy options to trade-off assessments of alternatives, prior to selection by the decision maker. The integration of more environmental attributes and socio-demographic factors into valuation models also seems necessary in order to enhance the potential for using valuation results in alternative policy contexts through more complete BT models.

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