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Analysis

An economic valuation of mangrove restoration in Brazil

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ABSTRACT

Mangrove forests are under considerable pressure in many developing countries and Brazil is not an exception to this problem. We investigate preferences for the restoration of mangrove areas in Brazil, using a choice experiment that varies the level and time of restoration. By interacting those attributes, we are able to identify nine potential scenarios that are expected to provide insight for policies and programs aimed to restore the threatened mangrove forest in the area. Conditional logit and scale heterogeneity multinomial logit models are estimated to analyze the respondents' choices. Our findings indicate that, out of the nine scenarios, respondents prefer a moderate restoration (i.e. vegetation health improvement of existing mangrove forest area) in less than 10 years. There also is a strong preference for complete restoration in 11 to 20 years, with complete restoration entailing vegetation health improvements and extension of the mangrove forest area of 20%. Results suggest that respondents understand that there are tradeoffs between levels and time of restoration.

1. Introduction

In many tropical coastal countries, the abundance of mangrove forests has declined dramatically over time (Blasco et al., 2001; Gini et al., 2011; Mijan Uddin et al., 2014; Okpiliya et al., 2013). Brazil is not an exception to this problem. In recent years, the state of Rio de Janeiro has lost a considerable area of mangrove forest primarily due to deforestation and the implementation of urban development projects (Kjerve et al., 1997; Bernini and Rezende, 2011). In addition, shrimp aquaculture, pollution and other factors have taken a toll. The Millennium Ecosystem Assessment has identified many ecological services originating from mangroves, and demonstrates how coastal communities depend on these ecological services (Millennium Ecosystem Assessment, 2005). Although it is clear that restoring mangroves would increase social welfare in Brazil, it is not clear that this should be a current focus of policy. Other environmental problems (e.g. pollution of rivers, treatment of sewage, loss of rainforests, greenhouse gas emissions, and loss of savanna) as well as a litany of social problems (e.g. poor access to education and health care, poverty, poor infrastructure) all compete for budget priority. Environmental valuation has the potential to contribute to the determination of priorities, by demonstrating the relative importance of mangroves to the proximate populations.

This paper examines the remaining mangroves in the Paraiba do Sul River estuary, located in the northern region of the Rio de Janeiro State. More specifically, the study performs a choice experiment to determine the value that the local population places on mangrove restoration programs with different potential restoration characteristics. Conditional multinomial logit and generalized multinomial logit (GMNL) models are estimated to analyze the respondents' choices. Estimation results indicate that, after controlling for taste and choice behavior heterogeneity, respondents have stronger preferences for restoring mangrove forest, and that this willingness to pay declines the longer the restoration process takes for completion, eventually reaching the point where willingness to pay disappears.

The remainder of the paper is divided into the following sections. Section 2 provides a general overview of the mangrove areas and the interaction that local people have with the resource. Section 3 presents the survey methodology and the choice experiment design. Section 4 introduces the analytical framework and econometric methodologies used to analyze the survey data. Section 5 presents the statistical analysis and results, and section 6 concludes the paper with a discussion of our findings and their policy implications.

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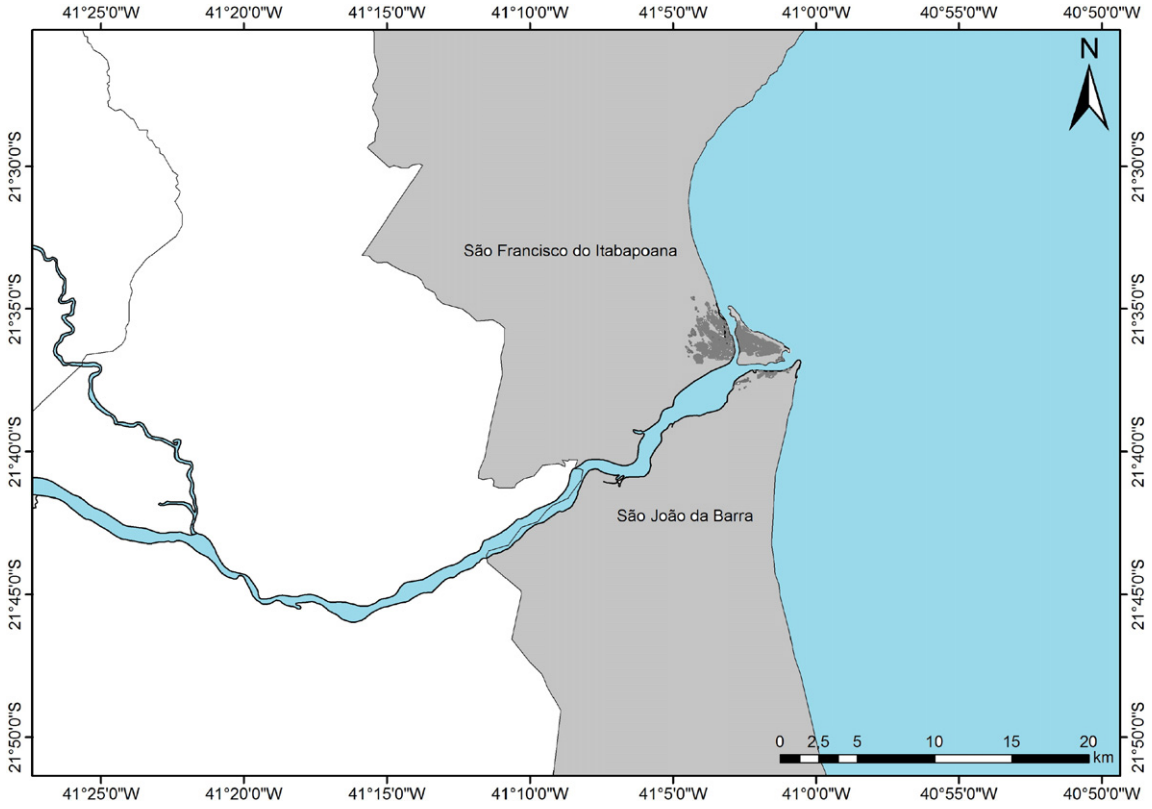

Fig. 1. Paraiba do Sul River estuary and the towns of São João da Barra and São Francisco de Itabapoana. Notes: The mangrove located in the external part of the estuary is highlighted.

2. Study Site

Our study was conducted in the counties (referred to as *municípios*[1] in Brazil) of São João da Barra and São Francisco de Itabapoana, in the northern region of Rio de Janeiro State, Brazil. São João da Barra has a land area of 455 km^2 and a total population of 32,747 as of 2010, with most of the inhabitants living in the urban center (79%). As of 2000, the poverty rate in São João da Barra was estimated at 36% (Ministério das Cidades, 2013a). São Francisco de Itabapoana is the second largest county in the state of Rio de Janeiro, with a land area of 1117 km^2 and a total population of 41,357 people, 51% of which live in the urban centers. Compared to São João da Barra, São Francisco de Itabapoana has a higher poverty rate estimated at 50% in 2000 (Ministério das Cidades, 2013b).

Those counties were chosen as our study site due to their geographic proximity to the Paraiba do Sul mangrove ecosystem, the largest mangrove area in northern Rio de Janeiro State. The Paraiba do Sul River estuary lies between São João da Barra and São Francisco de Itabapoana. The estuary has two outlets to the sea, the main estuary located in São João da Barra and the secondary estuary in São Francisco de Itabapoana (see Fig. 1). The mangrove provides a suite of ecological services, including supporting fisheries for households from neighboring communities, that focus on crab and other species (both vertebrates and invertebrates) (de Oliveira Côrtes et al., 2014; Kjerfve et al., 1997; Lacerda, 2002). Some of the other ecological services provided by the mangroves include a biogeochemical barrier against pollution (Lacerda et al., 1998), coastal stability, nutrient cycling, carbon sequestrations and organic matter for marine invertebrates and vertebrates (Rezende et al., 2007).

Currently, the Paraiba do Sul mangrove forest has an extension of approximately 725 ha (Bernini and Rezende, 2011). Approximately 53% of the Paraiba do Sul mangrove area is covered by black mangrove (*Avicennia germinans* [L.] Stearn.), 28% is covered by white mangrove (*Laguncularia racemosa* [L.] Gaertn f.), and the rest (19%) is red mangrove (*Rhizophora mangle* L.). This mangrove forest has suffered from many degrading activities, including deforestation, draining to create pastures, increasing urbanization, dredging, erosion, and siltation. As a result, the mangrove forest lost 20% of its coverage between 1986 and 2001 (Bernini and Rezende, 2011). Against this backdrop, the importance of mangrove restoration policies can be easily seen. Economic valuation of mangrove restoration may help design robust environmental policies in the region.

3. Survey Design and Implementation

3.1. Survey Design

Choice experiments (also known as choice modeling) have been used in a number of environmental applications to investigate the respondents' preferences for alternative states of the world that are defined by different levels of environmental attributes and cost of obtaining those attributes (e.g. Dissanayake and Ando, 2014; Casey et al., 2008). Choice experiments require careful design of the survey instrument and effective implementation in the field (Hoyos, 2010). Every choice experiment has five parts: 1) a description of the problem and potential solutions, 2) a set of questions about the environmental resource to get the respondent thinking about the resource, 3) a payment vehicle, 4) the choice sets, and 5) further questions including socioeconomic data. We carefully designed and implemented a survey questionnaire with each of these components in order to investigate local preferences for mangrove restoration programs in Brazil. We chose four attributes to describe the environmental changes and the policy (see Table 1). The first is the level of restoration (complete, moderate or minimal), the second is the time needed for the restoration to be accomplished (less than 10 years, 11 to 20 years, 21 to 40 years), the third is a monthly contribution to an NGO to finance the restoration effort (R$

[1] The *município* is similar to a county, in that it contains smaller cities, towns and communities, and the *municípios* completely span the physical territory of a state.