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Implications of a valuation study for ecological and social indicators associated with Everglades restoration

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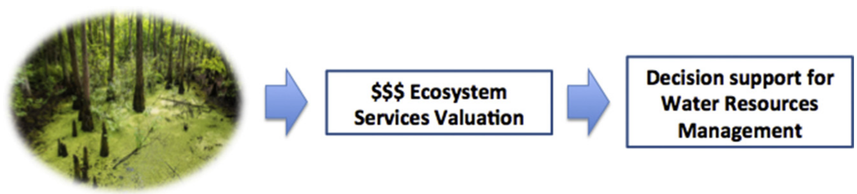
HIGHLIGHTS

- Re-evaluating public preferences towards Everglades restoration presents challenges.
- Willingness to pay for wetland species restoration produced values up to $1.2B
- The public highly favored species population restoration over hydrological restoration.

GRAPHICAL ABSTRACT



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ABSTRACT

The Everglades of south Florida, although degraded, imparts vital ecosystem benefits, including contributions to high quality drinking water supplies and habitat for a number of threatened and endangered species. Restoration of the Everglades can improve the provision of these benefits but also may impose tradeoffs with competing societal demands. This study focuses on understanding public preferences for Everglades restoration and estimating the willingness to pay (WTP) values for restored ecosystem services (ES) through the implementation of a discrete choice experiment (DCE). We collected data from 2302 respondents from the general public from an online survey designed to elicit WTP values for selected ecological and social attributes associated with Everglades restoration scenarios. We compare the findings to results from earlier studies (Milon et al., 1999; Milon and Scrogin, 2005), which also estimated WTP values among Floridians for Everglades restoration. For some attributes, WTP for Everglades restoration appears to have slightly increased while for others WTP appears to have decreased. We estimated statewide aggregate WTP values for components of species population restoration up to $2B over 10 years. Several factors impeded a direct comparison of current and historical WTP values, including time elapsed, different samples and sampling methods- which may have implications for integrating ecosystem service valuation studies into water management decisions.

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1. Introduction

As challenges continue to mount in the efforts to secure global freshwater supplies for future populations, re-evaluating the management of existing water resources is critical to fostering a sustainable future. South Florida is rich in water resources, and includes Lake Okeechobee, the second largest lake located entirely within the conterminous United States and the Florida Everglades, the largest subtropical wetland in North America (Richardson, 2010; Miao and Sklar, 1997; Davis Jr., 1943). Approximately 8.1 million people within a 16 county region rely on these systems for water supplies, and a significant amount of available water is devoted to meeting agricultural and environmental needs (SFWMD, 2018). The Everglades ecosystem has been degraded as a result of large-scale water management efforts over the past century to promote urban development and agriculture, and to reduce flooding in south Florida (Ogden et al., 2005). Current water management operations in south Florida result in an estimated 1.7 billion gal of

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freshwater lost each day to either the Gulf of Mexico or Atlantic Ocean (USACE and SFWMD, 1999). Reduced freshwater flows and the impacts of the levee-canal system, including declining water quality, have reduced habitat quality in the remnant Everglades. Sixty-eight plant and animal species occurring in the Everglades are now listed as threatened or endangered (Perry, 2004; Milon and Scrogin, 2005). Furthermore, the reduced freshwater flow throughout the Everglades has caused a decrease in hydraulic pressure in coastal aquifers, contributing to saltwater intrusion into urban and groundwater resources (Voss, 2000; Langevin, 2003).

As a consequence of ecosystem deterioration, the Everglades' ability to provision critical ecosystem services (ES) has significantly declined. The definition of ES in this study follows that proposed by Costanza et al. (1997), and expanded upon by Daily (1997) and Fisher and Turner (2008). The Everglades ecosystem provides many benefits for human populations including the provisioning of water supply for approximately one-third of Floridians and opportunities for recreation, including wildlife viewing, as it provides a habitat for various species (Richardson et al., 2014; Mathers, 2010). Efforts to enhance provisioning of these services are closely tied to the efforts to restore, at least partially, the historic water depths and overland flow volumes that characterized this system prior to its degradation. The Comprehensive Everglades Restoration Plan (CERP), a large- scale restoration effort initiated in 2000, was developed in response to the decline of the Everglades ecosystem and in recognition of the need to re-engineer the water management systems of south Florida. CERP also seeks to increase the amount of freshwater available for consumption within south Florida, while simultaneously improving habitat quality (McLean et al., 2002), including habitats for threatened, endangered, and many economically important species. The expansion of a stable water supply is an especially important component of CERP as the total population for south Florida (which includes Palm Beach, Broward, Miami-Dade, and Monroe counties) is expected to increase from 5.7 million people in 2012 to > 7 million people by 2040 (OEDR, 2014).

A few studies (Richardson et al., 2014; Mathers, 2010; Milon et al., 1999; Milon and Scrogin, 2005) have generated values for ES and other ecological components within the Everglades, using different methodologies, to inform regional decision-making by conveying in dollar values the benefits produced from restoration. The wide range of values for Everglades ES measured over the past 15 years creates significant uncertainty in water resources decision-making in this region. Repeated assessments of ES values using data collected through a stated-preference method, such as a choice experiment, can provide input for decision-makers by establishing how preferences and WTP values for water management and ecosystem restoration change over time, and in relation to other socio-economic drivers (Schneider and Braden, 2009; Braden et al., 2009).

Although conducted over 18 years ago, the survey results presented in Milon et al. (1999) represent the most recent attempt to utilize primary data collected through household surveys for valuing components of Everglades restoration. These data were further analyzed in Milon and Scrogin (2005). To the extent possible, we have replicated the methodology used by Milon et al. (1999) and relied on household survey data for the analyses. Unlike in Milon et al. (1999), our web based survey (described below) was distributed state-wide via email. We also analyzed separately a subset of responses from the counties (Miami- Dade, Orange, Palm Beach, Lee, and Hillsborough; hereafter referred to as the "*metro- county region*") originally surveyed by Milon et al. (1999) to facilitate comparisons with their results. The goal of this study is to provide updated estimates of economic values and public perception over time for Everglades restoration.

2. Materials and methods

2.1. Discrete choice experiment

A discrete choice experiment (DCE) is a stated preferences (SP) method used for economic valuation for ES and involves designing a contingent market scenario to elicit respondent's preferences and has become an increasingly popular stated preference technique for valuation of ES (Hoyos, 2010; Hanley et al., 1998). Based on random utility theory (RUT), a DCE decomposes an ecosystem good or service into key attributes with randomly assigned values in an experimental framework in which participating subjects are asked to state their preferences for these attributes. In this set-up, the individuals have to prioritize and assess their WTP for certain attributes while giving up others. DCEs are useful in assessing the tradeoffs respondents are willing to make between attributes (Boyer and Polasky, 2004) or more specifically, between ecosystem characteristics or goods and services and various social and economic welfare components (Westerberg et al., 2010; Johnston et al., 2011; Shoyama et al., 2013). The DCE framework employed for this study follows that of Milon et al. (1999) and seeks to determine the utility (U) of restoration to the stakeholders (i.e. Florida resident respondents to the survey described below) derived from their choice of payment for the attributes of alternative hydrological and species restoration scenarios:

$$U_{ij} = V_{ij}\ (X_{ij}, Z_i) + \varepsilon_{ij} \tag{1}$$

where, Uij, the utility of restoration option j to the stakeholder i is dependent on the wetland attributes (X) and the socio-economic characteristics (Z) of the stakeholder. According to RUT, the utility of the chosen restoration option is comprised of a deterministic component (V) and a random component (ε) which is independent of the deterministic part and follows a predetermined distribution (Birol et al., 2006). The stakeholder i will choose the restoration option j from choice set C_i if and only if $U_{ij} > U_{ik}$ ($j \neq k \in C_i$). According to the random utility hypothesis the probability that the respondent i will choose j over another alternative k can be stated by as follows

$$\begin{aligned} P_{ij} &= P\ (U_{ij} > U_{ik}) \\ &= P\ (V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}) \\ &= P\ (\varepsilon_{ij} - \varepsilon_{ik} > V_{ik} - V_{ij})\, \forall j \in C_i \end{aligned} \tag{2}$$

Assuming a linear relationship between the utility and the attribute variables and corresponding parameters, and with the random error term is identically and independently distributed across alternatives, the probability (P) of a stakeholder i choosing a particular restoration scenario j in choice set C_i can be expressed as follows (Greene, 2008), where β are parameters to be estimated by logit type regression models.

$$P_{ij} = \frac{\exp(V_{ij})}{\sum_{j=1}^{J} \exp(V_{ij})} = \frac{\exp\left(X'_{ij}\beta + Z'_i\gamma_i\right)}{\sum_{j=1}^{J} \exp\left(X'_{ij}\beta + Z'_i\gamma_i\right)} \tag{3}$$

The representative indirect utility function (V_{ij}), which is assumed to be linear in parameters can be estimated by the following specification:

$$Vij = \alpha + \beta_1 X_{1j} + \beta_2 X_{2j} + \ldots + \beta_n X_{nj} + \gamma_1 Z_1 + \gamma_2 Z_2 + \ldots + \gamma_i Z_i \tag{4}$$

where, X and Z represent restoration attributes and stakeholder's characteristics, and β and γ are corresponding regression coefficients to be estimated.

2.2. The Milon et al. (1999) study

Milon et al. (1999) focused on sampling within the Miami, West Palm Beach, Fort Myers, Tampa, and Orlando metropolitan areas, and organized several ecological and social attributes of developed and natural (Everglades) areas of the region into three distinct conceptual models: the hydrological, species, and socio-economic models. Each of these models contained a number of attributes for which respondents indicate their preference for a selection of a restoration option, or scenario. Attribute values were varied to represent potential outcomes of two different (partial or comprehensive) restoration scenarios. For

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