Latent preferences and valuation of wetland ecosystem restoration

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Abstract

This paper employs a latent class choice model to evaluate the effects of alternative ecological characterizations of wetland functions and services on preferences and to determine whether socioeconomic factors and psychometric measures of environmental attitudes can explain differences in individual's preferences and values for wetland restoration. Policy analysis for wetland ecosystems is difficult because these ecosystems provide multiple, interdependent services that vary by type of wetland, location, ecohydrological management, and other factors. This analysis combines a multiattribute choice model with information on individual's characteristics to evaluate preferences for restoration of the Greater Everglades ecosystem, one of the largest and most comprehensive wetland ecosystem restoration projects. To identify potential endpoints for Everglades restoration, two alternative ecological characterizations of the ecosystem were developed using the familiar distinction between function and structure. Survey data from a representative sample of the general population were used in a split-sample design based on the ecological characterization treatment. The latent class analysis identified three groups within each subsample who varied in their preferences for ecosystem restoration and socioeconomic profiles. The ecological characterizations had a significant influence on respondents' preferences and willingness to pay (WTP). The subsample responding to the structural characterization had a significantly larger share of respondents in the group who favored proposed restoration plans than the functional attribute subsample. In both subsamples, the group who favored restoration had a higher WTP for restoration than other groups. The latent class analysis also revealed socioeconomic and attitudinal factors that explain some of the heterogeneity in preferences and WTP within each subsample; this heterogeneity would not be identified with a standard choice model. In the context of Everglades restoration, the results provide a baseline assessment of public support and WTP that suggests an emphasis on structural rather than functional restoration endpoints. The approach described in this article can be used in other policy studies of wetland ecosystems because multiple ecosystem attributes can be represented within a stated choice survey and differences in preferences and values for these attributes can be identified.

Keywords: Wetlands; environmental values; latent class models; ecosystem services; Everglades

1. Introduction

Policy decisions about the environment are difficult because they involve complex ecological systems that can be evaluated in terms of different processes, scales and time periods. Understanding public preferences for changes in ecosystems is equally troublesome because of differences in: i) perceptions of ecosystem characteristics, ii) attitudes and norms about the environment, and iii) beliefs about the role of government in regulating human activities (Turner et al., 2003). Wetland ecosystems are a classic example of a complex ecological system requiring an integrated natural and social science approach to measure the economic value of wetland services for policy research (Turner et al., 2000).

Descriptions of wetlands emphasize a broad array of ecological functions and services associated with different types of wetlands and ecological scales (e.g., Mitsch and Gosselink 2000). Wetland ecosystems provide a mix of private and public services with both consumptive and nonconsumptive benefits. For economic valuation, these ecosystems are typically reduced to a subset of functions and services because standard valuation methods cannot encompass the complete set. Brouwer et al.'s (1999) and Woodward and Wiu's (2001) meta-analyses of wetland studies in the U.S., Canada and Europe found that most studies focused on a single wetland service. Morrison et al. (1999) and Carlsson et al. (2003) propose choice modeling as a method for valuation of the multiple services provided by wetlands. Other research indicates that individual attitudes and motives are important for understanding public values for environmental goods such as wetland ecosystem services (e.g., Blamey, 1998; Spash, 2000a,b; Rosenberger et al., 2003; Nunes and Schokkaert, 2003).

The objectives of this study are: i) to evaluate the effects of alternative ecological characterizations of wetland functions and services on preferences and ii) to determine whether socioeconomic factors and psychometric measures of environmental attitudes can be used to explain differences in individual preferences and values for wetland restoration. The analysis employs a latent class choice model in which stated choice data are combined with information about individual characteristics to identify groups sharing common preferences (Boxall and Adamowicz, 2002; Greene and Hensher, 2003; Heckman and Singer, 1984; Louviere, Hensher and Swait, 2000; McCutheon, 1987). Data were obtained from a household survey designed to elicit preferences for restoration of the Greater Everglades ecosystem, one of the largest and most comprehensive wetland ecosystem restoration projects (Walker and Solecki, 2001). Empirical results indicate that the characterization of wetland attributes had a significant effect on preferences for Everglades restoration. There was, however, a high degree of heterogeneity in preferences and values for wetland restoration regardless of the description used for wetland functions and services.

The next section provides background on Everglades restoration and details on the experimental design and survey administration. Section 3 describes the latent class approach for modeling choice along with the econometric analysis and valuation results for alternative restoration scenarios. We conclude with a summary of the analysis and a discussion of the implications of the findings for future research on preference elicitation and wetland ecosystem valuation.

2. Policy setting and experimental design

2.1 Background

The Greater Everglades ecosystem covers more than 69,000 square kilometers and is a mosaic of interrelated terrestrial, freshwater and marine systems. Undisturbed by humans until the beginning of the 20th century, extensive land use and hydrological changes reduced the spatial extent of the Everglades wetland system to less than 50 percent of its original area by 1990 and dramatically altered the natural flow of water (Davis and Ogden, 1994; Milon, Kiker and Lee, 1999; Sklar et al., 2001; Solecki, 2001). Despite decades of concerns expressed about the consequences of these changes on the remnant Everglades ecosystem (e.g., Douglas, 1948; Carter, 1974), it was not until the early 1990s that the U.S. Congress authorized initial efforts to evaluate the feasibility of restoration. These efforts culminated in the Comprehensive Everglades Restoration Plan (CERP) that was part of the Water Resource Development Act of 2000 (Public Law No. 106-541).[1]

While the CERP authorized a number of individual projects to begin restoration, it is a "conceptual blueprint" that does not explicitly define the final ecological endpoints (U.S. Army Corps of Engineers, 1999). These endpoints, along with detailed plans to achieve them, are to be developed over the next two decades through an adaptive assessment process. This process will utilize existing knowledge and new information about ecosystem reactions to the initial projects authorized in the CERP. Kiker, Milon and Hodges (2001) explain the importance of social science research in this process to assist in identifying and defining restoration endpoints. Unfortunately, the literature provides relatively little guidance on the types and extent of information needed to measure public preferences for complex environmental goods over time (Munro and Hanley, 1999; Turner et al., 2003). The experimental survey research described below was designed to contribute to the adaptive assessment process outlined in the CERP.

2.2 Experimental Design and Survey Administration

To provide a baseline assessment of public preferences and economic values for Everglades

[1] Additional information about the Comprehensive Everglades Restoration Plan is available at the website: http://www.evergladesplan.org.

restoration, a choice experiment was designed to utilize a multiattribute, paired comparison choice elicitation format (Louviere, Hensher and Swait, 2000). Two alternative ecological characterizations of the Everglades wetland ecosystem were used in the design based on the familiar distinction between the function and structure of an ecosystem (Bratton, 1992; Turner et al., 2000; U.S. Environmental Protection Agency, 2002).[2] In addition to serving as endpoints, these constructs provide a method to distill the complexity of the ecosystem into a manageable set of attributes for the purpose of describing the restoration process. By utilizing alternative, though not necessarily independent, descriptions of the ecosystem attributes it is possible to determine whether preferences for restoration vary with the type of information. In addition, the functional and structural distinctions are consistent with alternative approaches proposed to achieve Everglades restoration.

The functional characterization focused on spatial and temporal variations in water levels that influence the diversity of micro and meso habitats in the Everglades ecosystem (Holling et al., 1994). These variations are important for restoration because water levels are affected by urban and agricultural usage of available supplies within the region. The functional process was defined for each of three distinct hydrological subregions that were created through past water management decisions:

- water levels and timing in *Lake Okeechobee*;
- water levels and timing in the *Water Conservation Areas*; and
- water levels and timing in *Everglades National Park*.

[2] Turner et al. define wetland ecosystem *functions* as the interaction between the biotic and abiotic structure of a wetland and the dynamic processes of transforming matter or energy. The term ‘function’ is used here to represent the hydrological processes that sustain the Everglades ecosystem.

Alternative levels of restoration in each subregion were described by comparing hydrological conditions in the subregion to historic, predrainage conditions. The focus on the hydrological cycle and its management is the primary restoration strategy adopted in the initial CERP (U.S. Army Corps of Engineers, 1999).

The structural description of restoration was based on changes in population levels for groups of native fauna. A driving force for Everglades restoration has been concern about dramatic declines in the numbers of terrestrial and aquatic species over the past 50 years (Ogden, 1994). Therefore, the structural definition of restoration included three wildlife species groups:

- *wetland dependent species* such as wading birds and alligators;
- *dryland dependent species* such as deer, hawks and songbirds; and
- *estuarine (Florida Bay) dependent species* such as pink shrimp, mullet and sea trout.

Restoration levels for the species groups were defined by comparing population levels for each group to historic, predrainage levels. This view of restoration was outlined in the US Fish and Wildlife Service's (1999) plan that focused on recovery objectives for 68 threatened and endangered species in the region. Examples of the functional and structural attribute descriptions are provided in Tables 1 and 2, respectively.

To reflect other social objectives that must be considered in the design of Everglades restoration plans, the ecosystem attributes were combined with three additional attributes: the annual cost (price) of restoration to households, indoor and outdoor water use restrictions in South Florida, and conversion of farmland acreage to wetlands in South Florida. For both the functional and structural attribute designs, the choice task was framed as the selection of a preferred restoration alternative from the pair presented. A respondent was asked to choose the outcome that he/she personally preferred to avoid confusion about the motives for selecting an alternative (Ajzen et al., 1996; Andreoni, 1995; Spash, 2000a,b). A choice to maintain the status quo (no change in any attribute) was not included due to the Congressional mandate for restoration.

Alternative levels of the functional and structural attributes were selected in consultation with university scientists and agency staff who were knowledgeable about the Everglades ecosystem and the restoration effort. Three levels of each attribute were specified to represent baseline, intermediate and maximum possible restoration. Three levels were also specified for the social attributes. With a main effects design, there were 3^6 possible attribute combinations for both the functional and structural attribute descriptions. To reduce the number of possible choices, an optimized factorial design was used to select a subset of 27 possible combinations for each alternative attribute description. These combinations were blocked into two groups of seven paired comparison choices (with one alternative repeated across groups) to minimize the number of choice occasions.

The survey design was implemented using household interviews conducted by a professional marketing firm in five Florida cities (Miami, Fort Myers, Orlando, Tampa and West Palm Beach) with a stratified sampling plan based on census tract income and ethnic composition. The samples in each city were split evenly to give an equal proportion of participants in the functional and structural attribute treatment subsamples. Complete details on focus groups for the survey and the interview process are provided in Milon et al. (1999). A total of 480 interviews provided 1680 choices for each attribute set (seven choices times 240 respondents in each treatment subsample). A summary of the sample for each attribute treatment subsample is provided in Table 3. The sample means of the attributes are approximately equal to the midpoint of the upper and lower levels of each attribute because the choice set blocks were randomly distributed across the sample. Due to the random assignment of attribute sets and blocks, there were no differences in the socioeconomic characteristics of the subsamples in Table 3 ($P < 0.05$).

The interview design also included statements to measure respondent attitudes about environmental issues. The relationship between attitudes and expected behavior in valuation studies can be explained using Ajzen and Fishbein's (1980) theory of reasoned action (Ajzen, Brown and Rosenthal, 1996). The statements used in this survey were derived from the New Environmental Paradigm (NEP) index introduced by Dunlap and van Liere (1978). The NEP measures general environmental attitudes and has been used in the original and modified forms in a variety of studies (Dunlap et al., 2000). Kotchen and Reiling (2000) summarize the use of the NEP index in valuation research. Statements from the NEP were supplemented with statements to elicit attitudes about future water scarcity in Florida. Respondents were asked to rate each statement on a five-point Likert scale ranging from strongly agree (1) to strongly disagree (5).

Responses were factor analyzed using principal component analysis to develop psychometric measures of latent attitudes about the environment. Two attitudinal components were identified based on eigenvalues greater than or equal to 1.0. The survey statements and loadings for each statement are presented in Table A-1 in the Appendix. Scores for the two components, labeled as general environmental attitudes (GENV) and water scarcity attitudes (WSCAR), were calculated for each respondent. Summary statistics on the scores for the functional and structural attribute subsamples are presented in Table 3. A higher score on the GENV measure indicates stronger pro-environmental attitudes; a higher score on the WSCAR measure indicates greater concern about future water scarcity. Hypotheses tests for differences in the means of the attitudinal scores for the subsamples could not reject the null hypothesis ($P < 0.05$).

Regression analysis was also used to identify relationships between attitudinal scores and socioeconomic characteristics of the respondents. The results, presented in Table A-2, indicated little or no correlation for most characteristics and low overall explanatory power. One exception was age with a statistically significant, negative relationship for the GENV measure and a significant, positive relationship for WSCAR. Income was positively related to GENV but not to WSCAR. These results suggest that the psychometric and socioeconomic variables provide different measurements of the characteristics of each individual.

3. Econometric modeling and results

3.1 Latent class model specification

A number of alternative methods have been developed to evaluate data generated from stated choice experiments (Louviere, Hensher and Swait, 2000, pp. 138 – 212). The multinomial logit model (MNL), a standard in many previous studies, has been criticized because of the independence of irrelevant alternatives (IIA) assumption and its limited ability to accommodate heterogeneous preferences (e.g., McFadden and Train, 2000). For this analysis, a latent class model (LCM) is used because it provides a semiparametric alternative to the MNL that requires few assumptions about the distribution of preferences. The principle of LCM analysis is to evaluate choice behavior as a function of observable attributes of the choices and latent heterogeneity in the respondents, who are sorted into K classes based on statistical information criteria (Greene, 2003, pp. 439 − 447).

The LCM is specified as a random utility model with a deterministic component of utility and a random component:

$$U_{nj|k} = \beta_k X_{nj} + \varepsilon_{nj|k} \qquad (1)$$

where U is utility received by individual n from the jth alternative conditional on the individual being in group k, β is a vector of parameters over j alternatives, X is a vector of attributes of the j alternatives, and ε is the random component. Following the approaches used by Swait (1994), Roeder et al. (1999) and Boxall and Adamowicz (2002), the deterministic portion of utility can be separated into a component related to attributes of the choices and a latent component related to the socioeconomic and psychometric characteristics of the individual. The probability that individual n chooses j conditional on being in group k ($\Pr_{nj|k}$) can be expressed as the product of two probabilities:

$$\Pr_{nj|k} = \sum_{k=1}^{K} \left[\frac{\exp(\alpha_k S_n)}{\sum_{k=1}^{K} \exp(\alpha_k S_n)} \right] \left[\frac{\exp(\beta_k X_j)}{\sum_{j=1}^{J} \exp(\beta_k X_j)} \right] \qquad (2)$$

where α is a vector of parameters, S is a vector of socioeconomic and psychometric characteristics, and X is defined above. The first term in brackets represents the probability of observing the individual in group k. The second term represents the probability of choosing alternative j conditional on membership in k. The β_k are the marginal utilities of each attribute conditional on group membership. Error terms are assumed to be independently distributed across individuals and groups with a Type I extreme value distribution. The standard MNL model is a special case of the LCM because the joint probability in (2) reduces to the MNL model if $\alpha_k = 0$; the β_ks are then homogeneous and all individuals share a common utility function. The joint distribution in (2) is estimated simultaneously, but the number of group assignments is unknown apriori. Further, the number of groups is discrete and there is no rigorous method to select the optimal number. Most researchers have used a statistical information measure such as the Bayesian information criterion (BIC)(Schwartz, 1978) to guide selection of the number of groups (e.g. Roeder et al., 1999; Deb and Trivedi, 2002; Greene and Hensher, 2003).

In addition to providing a statistical basis for identifying latent groups with similar preferences, the LCM also provides information about the distribution of welfare effects associated with policy changes. For example, in the case of wetland restoration, each group's valuation of a change in some or all of the attributes of a wetland can be measured. Given estimates of the parameters in (2), the willingness to pay (compensating variation) for restoration of a wetland is given by the formula:

$$CV_{n/k} = \frac{1}{\beta_{ck}}\left[\ln\left(\sum_{j \in J}\exp(\beta_k X_j^0)\right) - \ln\left(\sum_{j \in J}\exp(\beta_k X_j^1)\right)\right] \quad (3)$$

where β_{ck} is the marginal utility of income, which is measured by a cost (price) variable included as an attribute (Small and Rosen, 1981; Hanemann, 1999). The variables X_j^0, X_j^1 represent the initial and post-restoration state of the wetland, respectively. Because β_{ck} and β_k vary across groups, the LCM framework identifies heterogeneity in the public's values for wetland restoration. This is noteworthy because these differences in preferences are obscured in a single aggregate measure with a MNL model.[3] The type and degree of restoration that can be evaluated in this framework depends on the specification of wetland attributes in the choice experiment design.

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[3] The formula in (3) for a MNL model would be:

$CV_n = \frac{1}{\beta_c}\left[\ln\left(\sum_{j \in J}\exp(\beta X_j^0)\right) - \ln\left(\sum_{j \in J}\exp(\beta X_j^1)\right)\right]$ where the variables are as defined above with the exception that there is no distinction in preferences for k groups. Note that (3) could also be weighted by the probability of group membership to construct an aggregate measure of welfare change (e.g., Boxall and Adamowicz, 2002).

3.2 Results

The empirical results are presented in two parts. First, the main econometric results are presented for the LCMs with the functional and structural attribute data. For completeness, a MNL analysis is also presented in order to evaluate the performance of the LCMs. The second section provides estimates of the willingness to pay for alternative levels of Everglades restoration for the groups identified in the LCM analysis.

3.2.1 Latent class model analysis

Initial estimation of the LCM with the functional and structural attribute data required an analysis of alternative group numbers (i.e., $k = 2, 3, 4$) using the BIC. Both the choice attributes and the socioeconomic characteristics described in Table 3 were used. The analysis revealed that a three group LCM provided the best solution for both attribute data sets.[4] Because each set includes different respondents from the overall sample, the three groups and the related socioeconomic characteristics differ in each LCM analysis.

Estimation results for the three group functional attribute model are presented in Table 4. For comparison, parameter estimates for a MNL model in which $k = 1$ are also presented. The estimation results reveal dramatic differences in preferences for Everglades restoration across groups and considerable heterogeneity in preferences for the wetland attributes. The positive, highly significant parameters for the three functional attributes for Group 1 indicate strong preferences for greater levels of Everglades restoration. For Group 2, the wetland attribute parameters were also positive but only the water conservation area attribute was statistically significant. On the other hand, the wetland attribute parameters for Group 3 were all negative,

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[4] Details of the group number analysis for the LCM model and the corresponding BIC statistics are available from the authors on request.

although only the Lake Okeechobee attribute parameter was statistically significant. The variation in parameter estimates across the groups contrasts with the positive estimates for these same parameters in the MNL model. The MNL 'averages' preferences across the three groups so the only statistically significant parameter was the water conservation area attribute.

Differences between the groups and the averaging effect of the MNL specification are also evident in the parameter estimates for the other choice model attributes. The negative parameters for the water restriction attributes indicate Groups 1 and 3 opposed restoration plans that limit household water use. Group 2 favored some restrictions. The averaging effect in the MNL indicated a negative response to severe restrictions on water use. Group 1 concurred with restoration plans that would reduce farmland acreage, but Groups 2 and 3 opposed this type of change. Both Groups 1 and 3 had negative parameters for the payment of higher utility taxes for Everglades restoration as economic theory would predict. Group 2, on the other hand, favored higher payments. The net effect in the MNL was a negative sign for the tax attribute.

The parameter estimates for the individual characteristic and attitudinal variables reported in the lower portion of Table 4 provide information about the socioeconomic sources of heterogeneity in preferences. The parameters for Group 3 are equal to 0 due to normalization in estimation; thus, Groups 1 and 2 are compared to Group 3. Gender and income were the only characteristics that were statistically significant for both groups. The negative parameter for gender indicates males were less likely to be members of either Group 1 or 2; the income parameter indicates higher income respondents were more likely to be in Groups 1 and 2.

The attitudinal variables were statistically significant for Groups 1 and 2. The parameter for GENV indicates respondents with stronger pro-environmental attitudes were more likely to be in Groups 1 and 2; this is consistent with the positive parameter estimates of the functional attributes for the two groups. Respondents who expressed more concern about future water scarcity were less likely to be in Groups 1 and 2. This result is not fully consistent with the negative response to household water restrictions by Group 1 but it is consistent with the positive response to these same restrictions by Group 2.

Considering the log-likelihood values and BIC statistic in the lower part of Table 4, the LCM outperforms the MNL. A log-likelihood ratio test rejects the MNL specification at the .01 level. The probability of membership in Groups 1, 2 and 3 were 22.4 percent, 31.0 percent and 46.6 percent, respectively. The LCM clearly provides a richer understanding of preferences for restoration of the Everglades ecosystem by identifying some of the differences in utility functions between the groups.

Analysis of latent preferences with the structural attribute model also illustrates the importance of identifying sources of differences in preference between groups. Estimation results for the structural attribute model are presented in Table 5. The results indicate sizable differences in preferences between Groups 1 and 3. For the three species attributes, Group 1 expressed negative preferences for species restoration while Group 3 expressed positive preferences. Parameter estimates for all three attributes were statistically significant for both groups. For Group 2, only the dryland species attribute was significant and negative. The averaging effect of the MNL across groups is evident once again with positive, statistically significant, parameter estimates for the wetland and estuarine species attributes and negative estimates for the dryland species attribute.

Further differences in the preferences of the groups are also exhibited by the parameter estimates for the other choice model attributes. The negative parameters for the water restriction attributes for Group 2 indicated clear opposition to restoration plans that would impose any limit on household water use. Group 3 indicated opposition only to severe water use restrictions while Group 1 had the rather confusing result that minor restrictions were opposed but more severe restrictions were favored. Group 3 opposed reductions in farmland acreage while Group 2 favored reductions; Group 1 was indifferent about this attribute. As in the LCM analysis with the functional attribute data, the utility tax attribute with the structural attribute data was negative and statistically significant for Groups 1 and 3. Group 2, however, favored higher payments.

The individual characteristic and attitudinal variables in the lower portion of Table 5 provide information about the sources of heterogeneity. The effects of these variables, however, are not as explicit as in the groups identified with the functional attribute data set. None of the variables were statistically significant across all groups. The positive parameter for gender indicates males were more likely to be members of Group 1. Despite Group 1's strong opposition to species restoration as defined with the functional attributes, the GENV parameter indicates this group's attitudes were not statistically different from the other two groups. Also, respondents who expressed greater concern about future water scarcity were less likely to be in Group 2 even though this group opposed any household water restrictions. Based on the log-likelihood values and BIC statistic in the lower part of Table 5, the LCM once again outperformed the MNL. In this case, the probability of membership in Group 3 was the highest, with 53.6 percent of the sample, while groups 1 and 2 had membership probabilities of 16.8 percent and 29.6 percent, respectively.

3.2.2 WTP for wetland restoration

To evaluate respondents' valuation of alternative restoration plans for the Everglades ecosystem, the estimated functional and structural latent class and MNL models were used to compute willingness to pay (WTP) measures. The LCMs provide information about the distribution of preferences (heterogeneity) across the groups and the effects of alternative descriptions of ecosystem attributes on these preferences. Simulated restoration plans were constructed according to partial and full restoration endpoint scenarios. The partial restoration scenarios involved independently changing each of the attributes from its base level condition to the highest level attainable for that ecosystem attribute. For example, partial restoration of Everglades National Park in the functional attribute specification would change water management so that water levels and timing within 90 percent of the area would be similar to historic, predrainage conditions rather than the current 50 percent of the area. Full restoration involved simultaneously changing all of the attributes from their base to the highest levels attainable. This approach was used with both the functional and structural descriptions of ecosystem attributes. Other choice model attributes (utility taxes, water restrictions and farmland acreage) were held constant at their base levels in these scenarios.

WTP estimates for the partial and full restoration endpoint scenarios with the functional and structural attribute sets are presented in Tables 6 and 7, respectively. The welfare estimates are defined for a representative respondent in each subsample from the MNL model and for a representative respondent within each of the LCM groups. The results for the functional attribute analysis (Table 6) illustrate the dramatic differences in preferences between Groups 1 and 3 and the averaging effect of the MNL model. WTPs for partial and full restoration endpoints are consistently positive for Group 1 but consistently negative for Group 3. No WTP estimates are presented for Group 2 because the positive parameter for the utility tax attribute in this group (Table 4) is inconsistent with the economic theory of welfare measurement underlying equation (3). Whether the responses by this group indicate the choices were non-compensatory or respondents were ambivalent about the choices presented cannot be determined within the design of this study. This inconsistency is not apparent, however, in the WTP estimates produced from the MNL model because the underlying heterogeneity is lost in aggregating preferences into a common utility function. The WTPs for a representative respondent with the MNL model are consistently positive but considerably smaller than for Group 1 because this group comprised the smallest percentage (22.4 percent) of the three groups (Table 4).

The results for comparable restoration scenarios with the structural attributes presented in Table 7 also reveal sharp differences in WTP. Group 1, which had negative responses to improvements in all ecosystem attributes in the structural attribute analysis, had consistently negative WTPs for the partial and full restoration scenarios. Group 3, on the other hand, had consistently large, positive WTPs for all scenarios. Group 2 is not represented because this group also had a positive parameter for the utility tax attribute (Table 5). WTP estimates with the MNL model obscure the differences in preferences between the groups which results in positive WTP estimates for two of the partial restoration scenarios and for full restoration. Note that the representative WTP for full restoration of the structural ecosystem attributes with the MNL model is approximately twice the WTP for full restoration of the functional ecosystem attributes with the MNL model ($59.26 vs $29.33). This difference occurs because 53.6 percent of respondents favored restoration (Group 3) in the structural attribute analysis whereas only 22.4 percent of respondents favored restoration (Group 1) in the functional attribute analysis.

The WTP results for the scenarios in Tables 6 and 7 provide strong evidence that the ecological characterization of wetland attributes had a significant influence on preferences for alternative restoration endpoints. Although the study design yielded two subsamples that were statistically equivalent in terms of socioeconomic and psychometric measures, the structural attribute subsample had a significantly larger percentage of respondents who favored the proposed restoration plans than the functional attribute subsample. The group who favored restoration within each subsample had a significantly different WTP for restoration than other respondents. The analysis also revealed some of the socioeconomic and psychometric factors that may account for preference heterogeneity. While the restoration endpoints that could result from either a functional or structural approach to Everglades restoration are not directly comparable, the findings suggest there would be greater public support for, and economic value derived from, an approach that gives priority to structural endpoints.

4. Summary and discussion

Our analysis demonstrates that social science research, and stated choice methods in particular, can provide useful information for complex environmental policy problems such as the restoration of wetland ecosystems. Policy analysis for wetland ecosystems is especially difficult because these ecosystems provide multiple, interdependent services that vary by type of wetland, location, ecohydrological management, and other factors. Given the diversity of wetlands and the services they provide, value elicitation and estimation methods are needed that can account for differences in public preferences for the multiple attributes provided by these ecosystems.

The study design and results described in this article indicate that LCM analysis can be used to identify how preferences for wetland ecosystem attributes vary between socioeconomic groups. The characterization of these attributes, however, as either functional or structural characteristics had a significant influence on respondents' preferences and WTP for alternative ecosystem restoration plans. The structural characterization elicited a significantly larger share of respondents who favored proposed restoration plans than the functional characterization. The analysis also revealed that socioeconomic and attitudinal factors can help to explain some of the variation in preferences for ecosystem attributes. The identification of these factors provides a richer understanding of the sources of heterogeneity in preferences than would occur if the underlying differences were ignored. In the context of Everglades restoration, the results provide a baseline assessment of public support and WTP within Florida that suggests an emphasis on structural rather than functional restoration endpoints. This baseline assessment should be compared to subsequent survey results as part of the ongoing adaptive assessment process required by the CERP to understand how public preferences respond to new information.

As noted elsewhere (e.g., Turner et al., 2003), additional research is needed to measure the economic values associated with the multiple, interdependent services provided by wetland ecosystems. The approach described in this article is promising because: i) multiple ecosystem attributes can be represented in stated choice surveys, and ii) differences in preferences and values for these attributes can be identified. To address an even broader array of wetland ecosystem attributes, it may be necessary to combine stated and revealed choice methods as employed for other policy problems (e.g. Louviere et al., 2000, pp. 227 – 251; Bhat and Castelar, 2002). In addition to maintaining a realistic cognitive burden for respondents, the combined approach could be more comprehensive. For example, prior research that has used residential property prices to measure economic values for proximity to wetlands (e.g., Mahan et al., 2000) could be enhanced with stated choice data to measure economic values for public goods such as ground water recharge and wildlife habitat.

The incorporation of socioeconomic and latent psychological factors in wetland valuation studies also promises to enhance the understanding of why some individuals value ecosystem services while others do not. Psychometric measures (such as the Environmental Response Inventory (Rosenberger et al., 2003)) that include a broader array of environmental attitudes than the NEP may enhance the explanatory power of choice models in differentiating between subgroups within the population. Also, ethical motives that are not fully captured in psychometric measures may help to explain preferences (e.g., Spash, 2000b). The practical difficulty for researchers will be to reconcile the time requirements that accompany more extensive psychometric inventories with the cognitive complexity that accompanies experimental designs with multiple ecosystem attributes. If the difficulties can be overcome, the LCM approach can be used to exploit the information in the enriched data sets. These developments offer new opportunities to measure the economic value of wetland ecosystem services.

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Table 1. Example of paired comparison choice with the functional attributes

Plan Component	A	B
Lake Okeechobee, Water Levels and Timing	**60%** of the time, lake levels and timing are similar to historic, predrainage conditions	**60%** of the time, lake levels and timing are similar to historic, predrainage conditions
Water Conservation Areas, Water Levels and Timing	**50%** of areas have water levels and timing similar to historic, predrainage conditions	**50%** of areas have water levels and timing similar to historic, predrainage conditions
Everglades National Park and Florida Bay, Water Levels and Timing	**90%** of the area has water levels and timing similar to historic, predrainage conditions	**50%** of the area has water levels and timing similar to historic, predrainage conditions
Annual Cost Per Household	Utility taxes **increased $25 per year or $250 over 10 years**	**No change** in utility taxes
Restrictions on Household Outdoor and Indoor Water Use	In dry years, outdoor use **restricted to 2 days per week**; indoor use **reduced by 25%**	In dry years, outdoor use **restricted to 3 days per week**; indoor use **reduced by 10%**
Farm land (acres) in the Everglades Agricultural Area and Western Portions of Palm Beach, Broward and Dade Counties	Reduce farm land acreage by **100,000 acres or 15% of farmed area**	**No change** in farm land acreage

Table 2. Example of paired comparison choice with the structural attributes

Plan Component	**A**	**B**
Wetland Dependent Species Such as Wading Birds and Alligators	**20%** of historic, predrainage population levels	**20%** of historic predrainage population levels
Dry Land Dependent Species Such as Deer, Hawks and Songbirds	**70%** of historic, predrainage population levels	**50%** of historic, predrainage population levels
Florida Bay Dependent Species Such as Pink Shrimp, Mullet and Sea Trout	**60%** of historic, predrainage population levels	**60%** of historic, predrainage population levels
Annual cost per household	Utility taxes **increased $25 per year or $250 over 10 years**	**No change** in utility taxes
Restrictions on outdoor and indoor household water use	In dry years, outdoor uses **restricted to 2 days per week** and indoor uses **reduced by 25%**	In dry years, outdoor uses **restricted to 3 days per week** and indoor uses **reduced by 10%**
Farm land in the Everglades Agricultural Area and western portions of Palm Beach, Broward and Dade counties	**Reduce** farm land acreage by **100,000 acres (15% of farmed area)**	**No change** in farm land acreage

Table 3. Variable definitions and summary statistics for the functional and structural attribute treatment subsamples

Attribute/Variable	Definition and Levels	Functional Attributes				Structural Attributes			
		Mean	S. D.	Min	Max	Mean	S.D	Min	Max
Lake Okeechobee	Percent of historic level: 60%, 75%, 90%	0.74	0.12	0.6	0.9	--	--	--	--
Water Conservation Areas	Percent of historic level: 50%, 75%, 90%	0.72	0.17	0.5	0.9	--	--	--	--
Everglades National Park	Percent of historic level: 50%, 75%, 90%	0.71	0.17	0.5	0.9	--	--	--	--
Wetland Species	Percent of historic level: 20%, 50%, 80%	--	--	--	--	0.49	0.25	0.2	0.8
Dryland Species	Percent of historic level: 50%, 60%, 70%	--	--	--	--	0.60	0.08	0.5	0.7
Estuarine Species	Percent of historic level: 60%, 75%, 90%	--	--	--	--	0.76	0.12	0.6	0.9
Annual Cost	Annual increase in utilities tax ($)	25	20.02	0	50	25	20.03	0	50
Water Restriction 1	1 if outdoor uses limited to 2 days per week & 25% decrease in indoor use consumption	0.36	0.48	0	1	0.36	0.48	0	1
Water Restriction 2	1 if outdoor uses limited to 1 day per week & 40% reduction in indoor use consumption	0.32	0.47	0	1	0.32	0.46	0	1
Farmland	Decrease in farmland acreage in South Florida ('000 acres)	99.84	80.19	0	200	99.88	80.19	0	200
Age	In years	49.15	17.31	19	86	47.35	18.19	19	89
Gender	1 if male, 0 female	0.48	0.50	0	1	0.48	0.50	0	1
White	1 if White, 0 otherwise	0.74	0.44	0	1	0.73	0.45	0	1
Black	1 if Black, 0 otherwise	0.09	0.28	0	1	0.09	0.29	0	1
Hispanic	1 if Hispanic, 0 otherwise	0.14	0.34	0	1	0.12	0.32	0	1
Income	1 to 9 by $10,000 increments (i.e. 1=less than $10,000, 2=$10,000 to $19,999, etc.)	4.04	2.05	1	9	4.21	2.09	1	9
GENV	Environmental attitude factor score	15.49	2.79	5	20	15.91	2.52	9	20
WSCAR	Water scarcity factor score	12.28	2.51	5	16	12.42	2.59	2	16

Table 4. Multinomial logit (MNL) and latent class model (LCM) parameters for the functional attributes and group determinants

Variables	*MNL*	*Groups*		
		1	*2*	*3*
Everglades National Park	0.445	12.760**	0.394	-0.543
	(0.338)	(2.742)	(0.502)	(0.372)
Water Conservation Areas	0.979**	13.597**	1.271**	-0.252
	(0.281)	(3.449)	(0.386)	(0.313)
Lake Okeechobee	0.364	5.213**	0.772	-0.997*
	(0.472)	(2.668)	(.675)	(-0.526)
Water Restriction 1	0.035	-3.805**	0.858**	0.103
	(0.114)	(-0.859)	(0.160)	(0.127)
Water Restriction 2	-0.404**	-3.455**	0.192	-0.365**
	(-0.103)	(-0.701)	(0.141)	(-0.112)
Farmland	-0.189**	0.721**	-0.269**	-0.319**
	(-0.056)	(0.266)	(-0.077)	(-.060)
Utility Tax	-0.014**	-0.062**	0.008*	-0.021**
	(-0.003)	(-0.019)	(0.004)	(0.003)
Intercept	-0.107	-0.613	0.057	-0.104
	(-0.076)	(-0.412)	(0.106)	(-0.085)
Age		0.019	0.071*	–
		(0.019)	(0.038)	
Gender		-1.281*	-3.634**	–
		(-0.734)	(-1.175)	
White		-10.667	-12.324	–
		(-49.561)	(-50.548)	
Black		-11.109	-22.860	–
		(-45.783)	(80.430)	
Hispanic		-10.242	-25.095	–
		(-50.532)	(87.556)	
Income		0.422**	0.669**	–
		(0.200)	(0.271)	
GENV Factor		0.338**	0.735**	–
		(0.167)	(0.227)	
Water Scarcity Factor		-0.194*	-0.420**	–
		(0.109)	(-0.186)	
Latent Class Probability		0.224	0.310	0.466
Log likelihood	-999.361		-929.840	
BIC[a]	1004.75		935.23	

[a]Bayesian Information Criterion (BIC) is defined as –LL+(Klog(n)/n) where K is the number of parameters and n is the number of observations (Greene, 2003, pp. 160).
* indicates the parameter is statistically different from 0 at the .10 level; ** indicates the parameter is statistically different from 0 at the .05 level

Table 5. Multinomial logit (MNL) and latent class model (LCM) parameters for the structural attributes and group determinants

Variables	*MNL*	*Groups*		
		1	*2*	*3*
Wetland Species	0.774**	-4.741**	0.278	1.309**
	(0.224)	(1.715)	(0.329)	(0.269)
Dryland Species	-1.392**	-10.486**	-4.948**	1.584**
	(0.642)	(3.312)	(1.036)	(0.750)
Estuarine Species	0.959**	-5.919**	-0.024	1.917**
	(0.359)	(2.113)	(0.551)	(0.411)
Water Restriction 1	-0.129	-1.091**	-0.263*	0.094
	(0.107)	(0.387)	(0.164)	(0.118)
Water Restriction 2	-0.381**	1.698**	-0.896**	-0.211**
	(0.099)	(0.659)	(0.151)	(0.111)
Farmland	-0.092*	-0.185	1.103**	-0.733**
	(0.054)	(0.339)	(0.113)	(0.073)
Utility Tax	-0.008**	-0.167**	0.018**	-0.009**
	(0.003)	(0.034)	(0.004)	(0.004)
Intercept	0.093	-0.264	0.017	0.192**
	(0.072)	(0.240)	(0.108)	(0.083)
Age		0.012	0.012	–
		(0.015)	(0.011)	
Gender		0.859*	0.275	–
		(0.563)	(0.398)	
White		-0.911	-1.367*	–
		(1.409)	(0.811)	
Black		-0.072	-0.843	–
		(1.541)	(0.961)	
Hispanic		1.664	-22.791	–
		(1.360)	(83.949)	
Income		-0.078	0.017	–
		(0.157)	(0.095)	
GENV Factor		-0.006	0.076	–
		(0.103)	(0.079)	
Water Scarcity Factor		-0.142	-0.199**	–
		(0.143)	(0.080)	
Latent Class Probability		0.168	0.296	0.536
Log likelihood	-1078.12		-1019.91	
BIC[a]	1083.58		1025.37	

[a]Bayesian Information Criterion (BIC) is defined as –LL+(Klog(n)/n) where K is the number of parameters and n is the number of observations (Greene, 2003, pp. 160).
[*] indicates the parameter is statistically different from 0 at the .10 level; [**] indicates the parameter is statistically different from 0 at the .05 level

Table 6. Willingness to pay for changes in the Everglades ecosystem using the functional attributes

Ecosystem Change	*MNL*	*Groups*		
		Group 1	*Group 2*	*Group 3*
Partial Restoration				
Everglades National Park	$7.95	$51.45	–	-$6.46
Water Conservation Areas	$17.48	$54.80	–	-$3.00
Lake Okeechobee	$3.90	$12.60	–	**-$7.12**
Full Restoration	$29.33	$195.27	–	-$29.37

Table 7. Willingness to pay for changes in the Everglades ecosystem using the structural attributes

Ecosystem Change	*MNL*	*Groups*		
		Group 1	*Group 2*	*Group 3*
Partial Restoration				
Wetland Species	$29.03	-$8.51	–	$43.67
Dryland Species	-$17.37	-$6.28	–	$17.56
Estuarine Species	$17.98	-$5.32	–	$32.00
Full Restoration	$59.26	-$40.23	–	$186.44

Table A-1. Principal component analysis of attitude statements about the environment and water scarcity.

Response Item	Factor 1	Factor 2
The environment is easily upset	**0.623**	0.209
Interference with environment produces disastrous results	**0.597**	0.225
Funding for environmental protection	**0.650**	0.068
Funding for endangered species protection	**0.727**	-0.217
Society has right to change the environment	**0.363**	-0.342
Future water scarcity in my community	0.140	**0.794**
Future water scarcity in Florida	0.259	**0.681**
Supply water to communities before the environment	-0.380	**0.586**
Everyone should use water conservation practices	0.279	**0.399**
Eigenvalues	2.321	1.768

Table A-2. Regression analysis for socioeconomic determinants of attitudinal factors

Variable	GENV Factor	Water Scarcity Factor
Intercept	15.616*	11.127*
	(0.701)	(0.646)
Age	-0.020*	0.031*
	(0.007)	(0.007)
Gender	0.227	0.345
	(0.249)	(0.229)
White	0.579	-0.770
	(0.569)	(0.524)
Black	-0.253	-0.205
	(-0.669)	(-0.617)
Hispanic	-0.387	0.356
	(0.644)	(0.594)
Income	0.131*	0.024
	(0.062)	(0.057)
Adjusted R^2	0.035	0.052