HETEROGENEOUS PREFERENCES AND COMPLEX ENVIRONMENTAL GOODS: THE CASE OF ECOSYSTEM RESTORATION

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Introduction

Environmental policy decisions involve diverse groups of citizens and dynamic ecological interactions. In economics, these policy problems are commonly modeled using simple components (e.g. homogeneous consumers and a single 'public good') in order to highlight the structure of the decision problem. While the assumption of homogeneity in individual preferences is effective for theoretical inquiries into the general properties of environmental problems, propositions based on preference homogeneity offer limited guidance on the distributional consequences of policy decisions involving national and local public goods. Yet with the recognition of heterogeneity across individuals or groups and multiple dimensions in environmental problems, the search for greater relevance may quickly become entangled in intractable complexity.

In this chapter, we investigate two sources of complexity in environmental policy: heterogeneous preferences over individuals and groups and complex environmental goods. Both concerns are receiving increasing attention in the economic literature. Economists (e.g. Layton 2000; Breffle and Morey 2000; Swallow et al. 1994; Train 1998) have utilized discrete choice techniques to model and measure heterogeneous preferences for public goods in order to: a) increase the explanatory power of environmental preference models and b) provide relevant information to policy makers about the distribution of public preferences. Other economists have begun to explore the implications of ecological complexity for economic analysis (e.g. Commons and Perrings 1992; Kahn and O'Neill 1999; Milon et al. 1999a; Turner et al. 1999). This has been a somewhat belated exploration since ecologists have a long-standing interest in alternative explanations for the variety and dynamics of natural systems and the complex relations within these systems (Holling 1987; Kolasa and Pickett 1991; May 1977).

In the following section we provide a discussion of some key issues in modeling heterogeneous preferences and complex environmental goods for public policy analysis. We then relate these issues to the problem of ecosystem restoration in the Florida Everglades. The Everglades/South Florida ecosystem covers more than 69 000 square kilometers and is a mosaic of interrelated terrestrial, freshwater and marine systems. The Everglades restoration, authorized by the US Congress in the Water Resources Development Act of 2000 (Public Law No. 106-541), is an $8 billion project that is one of the most extensive ecosystem restoration efforts undertaken anywhere in the world.[1] And, because of the unique mix of federal and state interests in the Everglades, it provides a classic example of the need for information about economic benefits to guide plan selection and cost-sharing decisions (Milon 2000). In Section 3 we provide details of a stated choice field experiment with proposed Everglades restoration plans including the survey design, data and econometric modeling issues. Section 4 presents empirical results and a discussion of the information provided from the heterogeneous preference models. We conclude with some observations on the role of heterogeneous preference modeling for policy decisions involving complex environmental goods.

Modeling preferences for complex environmental goods

The random utility model and heterogeneous preferences

The standard form to represent environmental preferences is in terms of utility, $\underline{U}$, for an environmental good. With alternative levels of the environmental good, more of the good is preferred to less if $\underline{U(A_2)} > \underline{U(A_1)}$ where $\underline{A_2}$ is a higher level of the good than $\underline{A_1}$. This framework can be generalised to consider alternatives that include multiple attributes of an environmental good using random utility theory. For a problem with two alternatives, *A* and *B*, assume an individual, denoted *n*, chooses the alternative with a higher level of utility or, in symbolic terms,

$$U_n(X^A) \geq U_n(X^B)$$

where $U_n(.)$ represents the individual's utility function and X^A, X^B represent sets comprised of *I* attributes for alternatives *A* and *B*. Utility can be decomposed into a systematic component, $v(.)$, determined by the attributes (i.e. $v_n(X^A) = v_n(X_1^A, X_2^A, \ldots, X_I^A)$) and a random component, ε_n, such that:

(1) $$U_n = v_n(X) + \varepsilon_n.$$

With either revealed or stated preference choice data from a representative sample of the public, statistical techniques such as multinomial logit (MNL) can be used to estimate the relative weights (marginal utility values) assigned to each attribute in the random utility model (RUM) (McFadden 1974; Louviere et al. 2000). These weights provide information about public preferences for both environmental and non-environmental attributes of the alternatives. In addition, the attribute weights can be used to estimate utility scores and welfare measures such as compensating variation (Roe et al. 1996; Swallow et al. 1994). These utility metrics can be used to compute rankings and aggregate willingness to pay for alternative bundles of attributes relative to the status quo.

The RUM can be evaluated under the assumption of homogeneous preferences by estimating an additive utility function of the form:

(2) $$U_n = X\beta + \varepsilon_n$$

where â is an I x 1 vector of weights associated with a vector of I attributes of the J alternatives. The marginal utilities ($â_i$s) are independent, so a change in the level of one attribute does not affect the value of another. Homogeneity yields a fixed effects model where â does not vary over individuals, implying that all individuals share a common utility function. Alternatively, the utility function can be specified in polynomial form (e.g. multiplicative or distributive), but the homogeneity property will be retained.

Heterogeneity can be introduced in the RUM framework by restricting â to be a function of observable socioeconomic characteristics (income, ethnicity, etc.) of the individual:

(3) $U_n = (S_m X)$â + $å_n$

where S_m represents a vector of m socioeconomic characteristics of the individual and â is an mI x 1 vector. With MNL estimation, this "classic" form of heterogeneity allows preferences (marginal utilities) for each attribute (or subsets of the attributes) to vary with socioeconomic characteristics and permits group-specific measures of environmental preferences to be estimated (e.g. Swallow et al. 1994).

An alternative form of heterogeneity can be introduced using random parameters logit (RPL) in which the coefficient vector or a subset of the coefficients varies randomly over individuals (Revelt and Train 1998, 1999; Train 1998). Individual preferences may be modeled:

(4) $U_n = X\alpha + X\alpha_n +$ $å_n$

where α represents a vector of mean population preferences and α_n represents a vector of the nth individual's preferences for the alternative. It is assumed that α_n and $å_n$ are independent. A variety of alternative assumptions about the distribution of preferences in the population (e.g. normal, lognormal, etc.) are permitted. This approach introduces heterogeneity into the preference measures but with a lack of specific information about how preferences vary across socioeconomic groups. Although highly flexible, this approach is sensitive to the decision regarding which coefficients are selected to be random and the estimation procedure (McFadden and Train 2000; Revelt and Train 1998, 1999).

An additional approach for introducing heterogeneity suggested by Revelt and Train (1999) and Breffle and Morey (2000) combines socioeconomic characteristics restrictions with RPL. The attribute vector is partitioned into *j* attributes with group-specific effects and *i* attributes with individual-specific effects. Specifically, preferences can be modeled as:

(5) $$U_n = (S_m X_j)\beta + X_i\alpha + X_i\alpha_n + \varepsilon_n$$

where the symbols are defined as above except now *j* attributes are modeled as socioeconomic group sources of heterogeneity and *i* attributes are modeled as individual (random) sources of heterogeneity. While this mixed approach provides a more comprehensive treatment of heterogeneity, there is little theoretical basis for partitioning the attributes into those with parameters that vary within the population and those that do not. Thus, explicit modeling of heterogeneity in environmental preferences with the mixed approach is largely determined by the data set and the estimation decisions of the researcher.

These modeling alternatives offer several choices for public preference research. The homogeneous preferences model (2) presents the simplest method to measure preferences yet important information about differences in preferences across the population cannot be identified. The classic heterogeneity model (3) permits differences in preferences to be identified across socioeconomic groups provided that information on individual characteristics exists in the data set. The basic and mixed random parameters models (4 and 5) can identify both group and individual sources of heterogeneity, but the appropriate choice of fixed and random parameters is primarily an empirical issue. And, because of the estimation procedure for the RPL, consistent parameters may be difficult to estimate with a large number of random parameters.

Attribute Specification for Complex Environmental Goods

While the preferred choice of modeling strategy to measure heterogeneity in environmental preferences is ambiguous, an additional complication is the representation of complex environmental goods in terms of measurable attributes. We define a complex environmental good as any bundle of two or more environmental resources that are related within or across ecological scales. Thus, predator-prey relationships, hierarchical biological communities and ecosystems are all examples of this classification. Single species or locations that have frequently been used in environmental preference studies are not complex environmental goods.

A difficulty with a complex environmental good is that there may be many perspectives on how to characterize the good's multiple attributes, especially in the context of ecosystem restoration (Bratton 1992; Franklin 1988; Holling 1987; Westman 1991). For example, one way to describe an ecosystem is by structural attributes such as population levels of individual and/or keystone species. Wildlife and aquatic species are a common way for the public to think about ecosystems (Wilson 1984; Kellert 1996), so representation of restoration alternatives through changes in the levels of species populations is likely to be easily understood. In the context of the Everglades/South Florida ecosystem, one of the primary driving forces for the restoration has been concern about dramatic declines in the number of wading birds over the past 50 years.

An alternative, though not necessarily independent, approach to describe an ecosystem is with functional attributes such as the periodicity of wetland flooding or the occurrence of natural successional processes. In an ecosystem such as the Everglades/South Florida system, the spatial and temporal process of wetting and drying determines the diversity of micro and meso habitats within the overall wetland-based ecosystem (Holling et al. 1994). This process is an especially important component of ecosystem restoration in South Florida because water availability for ecosystem functions is limited by urban and agricultural uses of available supplies.

For most complex ecosystems, structural and functional attributes represent different dimensions of the ecosystem, and the exact linkages between these attribute groupings are not well known. Moreover, the attribute groupings could be combined in a number of ways to describe the ecosystem depending on the ecological scale of interest (Noss 1990). The challenge for economists seeking to measure public preferences for policy alternatives that effect ecosystems is how to specify the attributes of the decision problem. Alternative specifications provide different information to respondents in a stated choice experiment. But, there is no consensus on the quantity or type of information that should be provided (Munro and Hanley 1999). A large number of interrelated attributes with multiple levels would lead to an intractable choice set. Collapsing the multiple dimensions into a single indicator may lack conceptually validity and fail to provide meaningful policy information.

The approach adopted in this study is to evaluate preferences under alternative specifications of the environmental good (i.e. functional or structural attributes). Ecosystem restoration based on increasing species levels may lead to different management actions than strategies based on restoring functional properties of the ecosystem (Bratton 1992; Westman 1991). In the context of Everglades restoration, more than 50 percent of the original land area of the Everglades has been converted to other uses, so it would be impossible to restore all functional and structural characteristics of the original ecosystem. A functional restoration strategy would emphasize the spatial and temporal dimensions of the hydrological cycle across the landscape of the Everglades. This is essentially the strategy used in the US Army Corps of Engineers' (1999) restoration plan for the Everglades that was approved by the US Congress in the Water Resources Development Act of 2000. Alternatively, a structural restoration strategy would seek to increase species population levels through changes in habitat suitability for specific communities, species groups and/or individual species. This approach to Everglades restoration is described in the US Fish and Wildlife Service's (1999) plan that focuses on recovery and restoration objectives for 68 threatened and endangered species. While neither strategy alone offers a comprehensive blueprint for restoration, it is important to understand how the public perceives an ecosystem in order to inform ecosystem managers about public preferences and willingness to pay for alternative types and degrees of ecosystem restoration.

Survey design and econometric modeling

To evaluate the effects of preference heterogeneity with alternative characterizations of ecosystem attributes, two multiattribute stated choice survey instruments were developed based on the RUM framework described above. One instrument was based on structural ecosystem characteristics and included native wildlife species groups classified as:

- 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.

These species groups have been identified as a principal concern of the restoration effort (US Fish and Wildlife Service 1999).

Alternatively, the second instrument was based on functional attributes which represented distinct hydrological subregions created through past water management actions. These attributes represented hydrological processes within three subregions:

- 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.

In addition, the fact that ecosystem restoration objectives in the Everglades/South Florida setting must be considered along with other social objectives, three additional attributes were developed as elements of any restoration plan. These attributes were:

- The annual cost of the restoration to households in Florida;
- Possible restrictions on outdoor and indoor water use in South Florida; and
- Changes in farmland acreage in South Florida through conversions to wetlands.

These latter three attributes were common to both the structural and functional attribute survey instruments.

Different levels of the structural and functional attributes were selected in consultation with scientists and agency staff knowledgeable about the Everglades ecosystem and the restoration effort. Three attribute levels were selected to represent a baseline (status quo) condition plus intermediate and maximum possible restoration relative to historical conditions (Milon et al. 1999b). In addition, three levels were specified for each of the social attributes to be included in the alternative plans. The combination of three levels for each of the six attributes with either the structural or functional representation of restoration plans results in 3^6, or 729, unique possible attribute combinations. To achieve a more manageable choice set while preserving statistical efficiency, an experimental design was selected based on an additive utility function to evaluate all main effects and first-order interactive effects.[2] Each attribute set for the survey was reduced to 27 combinations using an optimized, orthogonal factorial design (Louviere et al. 2000). The 27 possible combinations in the experimental design for both the structural and functional representations of attributes were further "blocked" into two groups of seven pair-wise choices (two groups times seven pair-wise choices equals 28 alternatives with one alternative repeated in each group) so that each respondent only made seven repeated choices. This simplification was based on pretesting and previous studies (e.g. De Palma et al. 1994) that indicated more than ten pair-wise choice tasks were too burdensome for respondents.

A total of 480 household interviews were conducted in five Florida cities in 1998 using randomly selected households from a stratified design based on census tract median income and ethnic composition. The cities were selected to represent the opinions of citizens in South Florida and Floridians in other parts of the state. A split sample design for the survey was used to give an equal proportion of respondents using the functional and structural attribute sets in each city. Examples of the pair-wise choice task used in the interviews for the functional and structural attributes are provided in Tables 1 and 2, respectively. A professional market research firm conducted the interviews; bilingual interviewers were used when necessary. Table 3 presents summary statistics for the survey data and respondent socioeconomic characteristics. The statistics show that the attribute means are approximately the midpoint of the upper and lower levels of each attribute. This occurred because the attribute combinations in the orthogonal factorial design were randomly distributed across the sample groups. The reader is referred to Milon et al. (1999b) for complete details regarding the initial focus groups, survey design, interview process and properties of the sample data. The 480 interviews provided 1,680 choices for each attribute set (seven choices times 240 respondents) based on the split sample design. Seven alternative RUM models were estimated for each of the structural and functional attribute data sets. The models were:

Model 1: An unrestricted MNL with only structural or functional attributes assuming homogeneous preferences for attributes $(\underline{X}\,\hat{a})$ – seven fixed parameters;

Model 2: A restricted MNL with socioeconomic interactions that allows for heterogeneous preferences across socioeconomic groups ($S_m X$â) – seven fixed parameters and 48 socioeconomic interaction parameters;

Model 3: An unrestricted RPL that allows heterogeneous preferences to vary randomly across individuals ($X\alpha \pm X\alpha_n$) – for estimation purposes only the price attribute was treated as a random coefficient;

Model 4: The same as Model 3 except 6 fixed parameter socioeconomic interaction variables are added for Income;

Model 5: The same as Model 3 except 12 fixed parameter socioeconomic interaction variables are added for Income and the Number of Years an Individual Lived in Florida;

Model 6: The same as Model 3 except 18 fixed parameter socioeconomic interaction variables are added for Income, the Number of Years an Individual Lived in Florida and the Region where a respondent lived (South Florida or Other);

Model 7: A fully mixed RPL with both socioeconomic group and individual heterogeneity (($S_m X_j$)â $\pm X_i\alpha \pm X_i\alpha_n$) that combines Model 3 with 48 fixed parameter socioeconomic interaction variables.

These alternative specifications allow the full range of heterogeneous preference models to be evaluated with the data sets and determine whether the degree and type of heterogeneity varies with the selection of attribute sets used to represent Everglades ecosystem restoration. For Models 1–7, estimation was performed with Gauss version 3.5 using the random parameter simulator (Train, Revelt and Ruud 1999).

Empirical results

Selected statistics from the estimation of Models 1–7 using the functional and structural attribute sets for Everglades restoration are presented in Table 4. To evaluate the extent of heterogeneity, the null hypothesis that homogeneity correctly characterizes preferences is tested using a log likelihood ratio comparing the unrestricted Model 1 with Models 2–7. Table 4 also reports the likelihood ratio test statistics and significance levels for the related chi-square (χ^2) distribution.

Results for the functional attribute models reported in the upper portion of Table 4 indicate that heterogeneity attributable to differences in preferences across socioeconomic groups is the dominant form of heterogeneity. In the case of Model 2 with socioeconomic interactions the null hypothesis of homogeneous preferences can be firmly rejected. On the other hand, the first of the random coefficients models, Model 3, provides no statistical improvement over the unrestricted Model 1. Although Models 4-6 show a continual improvement in the likelihood ratio statistic, none of these models performs better than Model 2. The final Model 7 with a random coefficient for price added to Model 2 provides a slight improvement in the likelihood ratio statistic, but the contribution is not significant. Thus, individual heterogeneity has little influence on preferences in this attribute model.

A similar conclusion emerges from the results for the structural attribute model for Everglades restoration in the lower portion of Table 4. A comparison of Model 3 with random coefficients to Model 1 using a likelihood ratio test indicates that the null hypothesis of homogeneous preferences would be rejected. The classic heterogeneity Model 2, however, would also reject homogeneity yet it proves superior to Model 3. The combined random coefficients and socioeconomic interactions in Model 7 also reject homogeneity, but the differences in results between Models 2 and 7 are once again not statistically significant. These results indicate that some individual heterogeneity is present in preferences for structural attributes, but differences in preferences across socioeconomic groups remains the primary source of heterogeneity.

To illustrate the influence of preference heterogeneity on policy options for Everglades restoration, a set of alternative hypothetical restoration plans was constructed based on the attributes in the functional and structural models. Two measures of preferences for each plan were then developed from the estimated utility function: 1) the "percent in favor" which is constructed by comparing the estimated utility score for a plan to the baseline utility value; and 2) the net willingness to pay (compensating variation) for the plan. The latter measure provides a benefit indicator of potential welfare changes. A comparison of these measures for homogeneous (Model 1) versus heterogeneous (Model 2) preferences reveals the influence of socioeconomic factors. Due to the similarity between the statistical results and preference measures for Models 2 and 7, only Model 2 results are reported here.

For example, Table 5 presents four alternative restoration plans and the baseline condition using the functional attribute data. The plans range from full Everglades restoration with none of the costs paid by Floridians (an environmental 'free lunch' courtesy of the US government) to full restoration with significant cost-sharing by Floridians. The last plan in Table 5 is included to show the effects of concerns about domestic water use restrictions in the plans. The two preference measures for "All" respondents in Table 5 assume homogeneous preferences while the heterogeneous preferences are displayed according to the sample respondent's location of residence in Florida (South vs Central). The results in Table 5 show significant variation in restoration preferences across location. Respondents in South Florida would be more likely to support restoration plans and display a significantly higher willingness to pay (WTP). The homogeneity model indicates almost three-fourths of respondents would support full restoration if it were costless, but the heterogeneity model reveals that less than a majority (48.9 percent) of

Central Floridians would favor this plan. Also, the net benefits (net WTP) for South Floridians would be more than ten times greater ($86.42 vs $8.24) than those for Central Floridians. While both South and Central groups would oppose a full restoration plan (and incur net losses) that imposed a significant cost-share burden (i.e. full restoration with all costs), South Floridians would support and receive positive net benefits ($11.90) from full restoration if the plan imposed no water use restrictions.

Similar results emerge from Table 6 which uses the same set of restoration plans based on the functional attribute model except preferences are measured by the respondent's past donations to environmental groups. This variable (see Table 3) is a proxy for environmental attitudes that have been shown to be important determinants of preferences for environmental goods (Bateman and Willis 1999). The results in Table 6 again show that heterogeneity is important. Donors to environmental groups are much more likely to favor any restoration plan and have a significantly higher WTP than non-donors. Even donors, however, would incur a net welfare loss from a full restoration plan that included a significant cost-share burden for Floridians. Note also that this disaggregation of preferences reveals that both groups are sensitive to whether water use restrictions are imposed as part of the restoration plan.

A comparable evaluation was conducted with the structural attribute model to determine how preferences were influenced by selection of the attribute set to represent the Everglades ecosystem. Table 7 presents four alternative restoration plans and the baseline condition using the structural attribute model. The plans range from full ecosystem restoration with none of the costs paid by Floridians to full restoration and significant cost-sharing by Floridians. In this case the restoration plans focus on wetland and estuarine species restoration because there would be direct substitution between wetland and dryland habitats. The last plan in Table 7 is again included to identify the effects of concerns about domestic water use restrictions in the plans.

The results in Table 7 with preferences disaggregated by location indicate that preferences for the structural attributes also differed across individuals. While both groups strongly favored full restoration with no costs, in this analysis Central Floridians were more likely to favor other restoration plans and to have a higher WTP for these plans than South Floridians. Both groups would oppose full restoration with a high cost-share for Floridians (as in the functional attribute analysis), but the magnitude of the potential welfare loss is smaller for both groups than with the functional attribute model.

Finally, Table 8 presents the same set of restoration plans as Table 7 except preferences were disaggregated according to whether the respondent had donated to environmental groups. Again both groups strongly favor full restoration with no costs, and those who donated to environmental groups had stronger preferences for restoration than those who had not. But, the differences between group preferences for other plans were much smaller than with the functional attribute model. Also, both groups were very sensitive to the extent of water use restrictions.

Discussion and Conclusions

In this study we investigated two sources of complexity in environmental policy: heterogeneous preferences over individuals and groups and multiattribute environmental goods. Our analysis and results were based on a choice experiment using stated preference models for Everglades ecosystem restoration. This project is one of the most extensive and expensive restoration efforts ever undertaken and a classic example of the need for public preference information to guide plan selection and cost-sharing decisions.

Our results suggest that policy analysis based on assumptions about homogeneous preferences may provide incomplete and/or inaccurate information to policymakers. The analysis indicated that disaggregation of preferences by socioeconomic groupings may yield widely differing evaluations of the same restoration plan. For example, if the net willingness to pay estimates from the homogeneous preference model in Table 5 were extrapolated to Florida's 2000 population of 5.82 million households[3], the aggregate annual net benefits for full functional restoration (with no direct costs to Floridians) would be $342.2 million ($58.79 times 5.82 million). By contrast, because 40 percent of all households reside in South Florida, the heterogeneous preference model (Table 5) yields annual benefits of $201.2 million for South Floridians and $28.8 million for other Floridians. Total net benefits of $230.0 million are significantly lower with the heterogeneous model. A similar divergence would result for the other policy alternatives in Table 5 or if the net benefit results were extrapolated on the basis of past environmental donations as presented in Table 6. Thus, the homogeneous preference model would overstate annual aggregate benefits for the same policy alternative by a significant margin.

On the other hand, the structural attributes model did not indicate a wide divergence in preferences between South Floridians and other Florida residents. The results in Table 7 for the homogeneous preference model produce an aggregate annual net benefit of $406.6 million ($69.86 times 5.82 million) for full structural (wetland species) restoration with no direct costs to Floridians. With the heterogeneous preference model, annual net benefits from full restoration would be $160.2 million for South Floridians and $252.9 million for other Floridians, a total of $413.1 million. Similarly, there would be a relatively small difference in the aggregate net benefits if the estimates in Table 8 were extrapolated on the basis of past environmental donations.

These aggregate benefits for alternative restoration plans can be compared with the estimated $400 million average annual cost (over 20 years) for the US Army Corps of Engineers' (1999) Everglades restoration plan. With both the functional and structural attributes models, the average annual net benefits would not justify the project unless there were no direct costs to Florida residents. This comparison, however, should be used with caution because the restoration alternatives used in this study do no match exactly with the actual Corps' plan. And, possible benefits from Everglades restoration plans to individuals outside Florida have not been measured. Moreover, it should be noted that the US Congress exempted the Everglades restoration project from the standard water resource planning requirement for a benefit-cost analysis (Milon 2000).

Nevertheless, the empirical evidence from this choice experiment indicates that the type of information provided to respondents about complex environmental goods does matter in the elicitation of environmental preferences. Structural and functional attributes represent two alternative, albeit interrelated, ways to represent a complex environmental good. Both descriptors are consistent with ecological approaches to ecosystem restoration and have policy relevance.

Respondents generally preferred some level of Everglades restoration regardless of the attribute specification. Individuals who lived outside South Florida and those who had not made environmental donations in the past had much weaker preferences for restoration when the restoration plans were specified with functional attributes. Unfortunately, the differences between stated preferences with alternative ecological information are not easy to explain. It is tempting to attribute these differences in preference intensity solely to the socioeconomic characteristics identified in this study. But, as Munro and Hanley (1999) point out, economic theory provides relatively limited guidance on the relationship between environmental information and individual values. The observed socioeconomic characteristics used in this analysis may be proxies for more fundamental attitudes and/or knowledge about ecosystem processes that influence environmental preferences (e.g. Kotchen and Reiling 2000).

Nevertheless, these results indicate that further research is warranted into the effects of alternative types of information about complex environmental goods in stated choice surveys.

In summary, empirical public policy analyses such as the choice experiments used in this study are difficult and expensive to conduct. The evaluation of heterogeneity in public preferences and the specification of choice attributes for complex environmental goods raise many difficult issues for survey design and econometric analysis. The search for improved methods to deal with these sources of complexity could significantly enhance the information available for environmental policy decisions.

Notes

1. Complete information about the Everglades restoration project is available through the website: http://www.evergladesplan.org.

2. For completeness other utility functions with multiple interaction effects could have been evaluated, but this would have significantly increased the scope and extent of the experiment. Louviere et al. (2000) succinctly summarize this research dilemma in their observation that additivity of utility should be regarded from the outset as very naï ve and simplistic. Yet, with more complex problems, it may not be practical (or even possible) to use designs that provide efficient estimates of main effects and multiple interactions. "Hence, in many cases, one must use main effects designs or do nothing" (Louviere et al. 2000, p. 88).

3. The willingness to pay estimates were extrapolated on the basis of household units because this was the sampling unit in the survey design. Also, the cost attribute used in the multiattribute models was expressed in terms of annual household costs.

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Table 1. Example of Pair-wise Choice for the Functional Attribute Model

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
Everglades 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	**Increased $25 per year**	**No change**
Restrictions on Household Outdoor and Indoor Water Use	Outdoor use limited to 2 days per week; indoor use **reduced 25%**	Outdoor use limited to 3 days per week; indoor use **reduced 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 Pair-wise Choice for the Structural Attribute Model

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 Models

Attribute/Variable	Definition	Functional Attribute Models				Structural Attribute Models			
		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 Area	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	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	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
Political Party	1 if Republican, 0 otherwise	0.25	0.44	0	1	0.27	0.44	0	1
Region	1 if Central Florida, 0 South Florida	0.41	0.49	0	1	0.39	0.49	0	1
Donations	1 if donated to environmental groups, 0 otherwise	0.42	0.49	0	1	0.49	0.50	0	1

Gender	1 if male, 0 female	0.48	0.50	0	1	0.48	0.50	0	1
Years in Florida	Number of years as resident	20.24	14.09	1	73	18.71	12.69	1	71
Income	1 to 9 by $10,000 increments (i.e. 1=less than $10,000, 2=$10,000 to $19,999, etc.)	4.07	2.06	1	9	4.26	2.08	1	9
Ethnic 1	1 if White-Hispanic or Black-Hispanic, 0 otherwise	0.14	0.35	0	1	0.12	0.33	0	1
Ethnic 2	1 if White-Non-Hispanic, 0 otherwise	0.74	0.44	0	1	0.73	0.45	0	1

Table 4: Estimation Results for Homogeneous and Heterogeneous Preference Models 1 – 7 with Functional and Structural Attributes

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Number of parameters	7	55	8	14	20	26	56
Functional							
Log-likelihood	-1,000.36	-950.41	-1000.36	-985.94	-980.81	-975.60	-949.36
Pseudo R^2	0.14	0.18	0.14	0.15	0.16	0.16	0.18
LR Test statistic	---	99.92***	0.00	28.85***	39.10***	49.52***	102.00***
Structural							
Log-likelihood	-1,078.96	-1046.72	-1,074.91	-1,068.33	-1,064.21	-1,060.41	-1,045.65
Pseudo R^2	0.05	0.08	0.05	0.06	0.06	0.07	0.08
LR Test statistic	---	64.48*	8.10***	21.26***	29.50***	37.09***	66.61**

Notes: ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 5. Evaluation of Selected Restoration Plans with the Functional Attribute Models by Respondent Location

Plan Description	Percent in Favor			Net Willingness to Pay ($ per year)		
	All	South	Central	All	South	Central
Baseline (no change) Hydrology. Lake Okeechobee: 60% Costs: 0 Water Conservation: 50% Farmland Reduction: 0 Everglades National Park: 50% Water Restriction: none	NA	NA	NA	NA	NA	NA
Full Functional Restoration without Costs. Lake Okeechobee: 90% Costs: 0 Water Conservation: 90% Farmland Reduction: 0 Everglades National Park: 90% Water Restriction: none	71.7	87.6	48.9	$58.79	$86.42	$8.24
Full Restoration with Minimized Costs. Lake Okeechobee: 90% Costs: $25 Water Conservation: 90% Farmland Reduction: 100,000 Everglades National Park: 90% Water Restriction: Level 1	54.3	69.0	33.3	$15.60	$41.43	-$39.41
Full Restoration with All Costs. Lake Okeechobee: 90% Costs: $50 Water Conservation: 90% Farmland Reduction: 200,000 Everglades National Park: 90% Water Restriction: Level 2	31.1	43.4	13.3	-$61.09	-$22.11	-$131.65
Full Restoration with All Costs/No Water Restrictions. Lake Okeechobee: 90% Costs: $50 Water Conservation: 90% Farmland Reduction: 200,000 Everglades National Park: 90% Water Restriction: none	41.6	58.9	16.7	-$23.99	$11.90	-$83.01

NA – Not Applicable

Table 6. Evaluation of Selected Restoration Plans with the Functional Attribute Models by Past Environmental Donations

Plan Description	Percent in Favor			Net Willingness to Pay ($ per year)		
	All	Donate	No Donations	All	Donate	No Donations
Baseline (no change). Lake Okeechobee: 60% Costs: 0 Water Conservation: 50% Farmland Reduction: 0 Everglades National Park: 50% Water Restriction: none	NA	NA	NA	NA	NA	NA
Full Functional Restoration without Costs. Lake Okeechobee: 90% Costs: 0 Water Conservation: 90% Farmland Reduction: 0 Everglades National Park: 90% Water Restriction: none	71.7	90.1	58.6	$58.79	$92.26	$27.35
Full Restoration with Minimized Costs. Lake Okeechobee: 90% Costs: $25 Water Conservation: 90% Farmland Reduction: 100,000 Everglades National Park: 90% Water Restriction: Level 1	54.3	75.8	39.1	$15.60	$41.78	-$30.93
Full Restoration with All Costs. Lake Okeechobee: 90% Costs: $50 Water Conservation: 90% Farmland Reduction: 200,000 Everglades National Park: 90% Water Restriction: Level 2	31.1	52.7	15.6	-$61.09	-$7.68	-$109.35
Full Restoration with All Costs/No Water Restrictions. Lake Okeechobee: 90% Costs: $50 Water Conservation: 90% Farmland Reduction: 200,000 Everglades National Park: 90% Water Restriction: none	41.6	60.4	28.1	-$23.99	$12.86	-$55.47

NA – Not Applicable

Table 7. Evaluation of Selected Restoration Plans with the Structural Attribute Models by Respondent Location

Plan Description	Percent in Favor			Net Willingness to Pay ($ per year)		
	All	South	Central	All	South	Central
Baseline (no change). Wetland Species: 20% Costs: 0 Dryland Species: 50% Farmland Reduction: 0 Estuarine Species: 60% Water Restriction: none	NA	NA	NA	NA	NA	NA
Full Structural (Wetland Species) Restoration w/o Costs. Wetland Species: 80% Costs: 0 Dryland Species: 50% Farmland Reduction: 0 Estuarine Species: 90% Water Restriction: none	92.7	88.7	98.9	$69.86	$68.82	$72.42
Full Restoration with Minimized Costs. Wetland Species: 80% Costs: $25 Dryland Species: 50% Farmland Reduction: 100,000 acres Estuarine Species: 90% Water Restriction: Level 1	67.9	54.9	88.0	$26.63	$12.02	$50.58
Full Restoration with All Costs. Wetland Species: 80% Costs: $50 Dryland Species: 50% Farmland Reduction: 200,000 acres Estuarine Species: 90% Water Restriction: Level 2	29.9	26.1	35.9	-$33.64	-$47.85	-$12.63
Full Restoration with All Costs/No Water Restrictions. Wetland Species: 80% Costs: $50 Dryland Species: 50% Farmland Reduction: 200,000 acres Estuarine Species: 90% Water Restriction: none	52.1	43.7	65.2	$1.32	-$12.62	$24.50

NA – Not Applicable

Table 8. Evaluation of Selected Restoration Plans with the Structural Attribute Models by Past Environmental Donations

Plan Description	Percent in Favor			Net Willingness to Pay ($ per year)		
	All	**Donate**	**No Donations**	**All**	**Donate**	**No Donations**
Baseline (no change). Wetland Species: 20% Costs: 0 Dryland Species: 50% Farmland Reduction: 0 Estuarine Species: 60% Water Restriction: none	NA	NA	NA	NA	NA	NA
Full Structural (Wetland Species) Restoration w/o Costs. Wetland Species: 80% Costs: 0 Dryland Species: 50% Farmland Reduction: 0 Estuarine Species: 90% Water Restriction: none	92.7	93.0	92.4	$69.86	$73.37	$67.23
Full Restoration with Minimized Costs. Wetland Species: 80% Costs: $25 Dryland Species: 50% Farmland Reduction: 100,000 acres Estuarine Species: 90% Water Restriction: Level 1	67.9	76.5	59.7	$26.63	$37.81	$15.00
Full Restoration with All Costs. Wetland Species: 80% Costs: $50 Dryland Species: 50% Farmland Reduction: 200,000 acres Estuarine Species: 90% Water Restriction: Level 2	29.9	35.7	24.4	-$33.64	-$19.93	-$47.59
Full Restoration with All Costs/No Water Restrictions. Wetland Species: 80% Costs: $50 Dryland Species: 50% Farmland Reduction: 200,000 acres Estuarine Species: 90% Water Restriction: none	52.1	53.9	50.4	$1.32	$8.71	-$4.52

NA – Not Applicable