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November 2005

Working Paper # 05031

Department of Economics Working Papers Series

Ames, Iowa 50011

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Preliminary Draft – Please do no quote without permission

September 9, 2008

* The authors would like to thank Cathy Kling and three anonymous referees for their helpful comments and suggestions regarding an earlier draft of this paper and Greg Colson with his help preparing the data for analysis. Funding for the Iowa Lakes Project data used in this analysis was provided by the U.S. Environmental Protection Agency's Science to Achieve Results (STAR) program. Although the research described in the article has been funded in part by the U.S. Environmental Protection Agency's STAR program through grant R830818, it has not been subjected to any EPA review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

I. Introduction

The recreation demand model provides one approach to estimating benefits of water quality improvements. However, this approach is often limited by the range of variation in observed qualities. To address this limitation, the recreation demand literature increasingly makes use of contingent behavior (CB) data. In the CB framework, respondents are asked how their pattern of trips to a site (or set of sites) would change given a proposed water quality change. Thus, combining observed data with CB data allows the analyst to estimate the impact of water quality improvements on trip behavior beyond the observed variation. Further, even when quality variation already exists, the additional variation provided by CB data will generally yield more precisely estimated recreation demand parameters. However, relatively little is known as to whether the stated responses to these hypothetical quality changes are consistent with how households respond to actual quality changes. The question is: Do individuals respond to hypothetical water quality changes in the same way that they respond to actual water quality changes? Do they respond more to hypothetical water quality changes (e.g., with the hope of influencing policy changes or because they ignore their budget constraint)? Alternatively, do they respond less because they do not believe that the changes will actually occur?

The purpose of this paper is to investigate individuals' responses to a hypothetical water quality improvement. Toward this end, we jointly model the recreation lake usage in Iowa using observed and CB trip data collected from the 2004 Iowa Lakes Survey. The Iowa Lakes Survey collected three sets of trip data for 131 lakes in the state: (a) actual trips in 2004, (b) anticipated trips in 2005 to the same lakes given current lake conditions and (c) anticipated trips in 2005 given hypothetical improvements to a subset of the lakes. The hypothetical improvement was described in terms of EPA's water quality ladder index. Specifically, the hypothetical water scenario proposed improving all of the lakes in the set to be at least safe for swimming, with a water quality index of 7. The three types of recreation demand data provide a unique

opportunity to investigate the convergent validity of individual responses to actual versus hypothetical environmental conditions.

The remainder of this paper is divided into five sections. Section II provides a review of the existing literature on the estimation of the recreation demand using both stated and revealed preference data. Section III describes the observed and CB trip patterns under the current water quality and the hypothetically improved water quality levels collected in the Iowa Lake Survey 2004. The repeated mixed logit model (RXL) used in the analysis is then described in Section IV. Estimation results are discussed on Section V, with Section VI providing conclusions.

II. Literature

A number of recent recreation demand studies have combined observed and contingent behavior data in order to better understand how households respond to changing environmental conditions. Adamowicz *et al.* (1994), for example, compare site selection choices estimated from actual data versus those anticipated under hypothetical scenarios. Both Englin and Cameron (1996) and Azevedo, Herriges and Kling (2003) combined data on the number of trips actually taken with intended numbers of trips given alternative trip costs. Layman, Boyce, and Criddle (1996) combine observed travel cost data and hypothetical travel cost data to estimate the value of three alternative recreational fishing management proposals. Loomis (1997) uses information on actual trips at current trip costs, intended visitation at higher trip costs, and intended visitation with two proposed quality changes. Finally, Grijalva *et al.* (2002) use three types of mountain climbing data: prepolicy observed climbing trip data, CB climbing trip data given hypothetical changes in site access, and postpolicy observed climbing trip data. The CB trip data consisted of two hypothetical policy scenarios: One is the closure of one site and the other is the closure of two sites. They show that policy changes induce significant changes in consumer surplus.

The primary point of most of the above studies is to illustrate the benefits of combining

observed and contingent behavior trip data for the valuation of environmental quality changes. One such advantage is the ability to consider quality and price changes that are policy relevant but historically unobservable (Adamowicz *et al.*, 1994; Englin and Cameron, 1996; Grijalva *et al.*, 2002; and Cameron, *et. al.*, 1996). Adamowicz *et al.* (1994) also state that the multicollinearity among quality characteristics that is often present in observed data can be reduced through the strategic design of quality levels in the contingent behavior portion of the survey. In addition, Ben-Akiva and Morikawa (1990) show that combining these two data sets increases the accuracy of the parameter estimates over models using either type of data alone.

Considerably less attention has been paid in the literature to testing the validity of individual responses to contingent behavior scenarios; i.e., whether observed and contingent behavior data are consistent with the same underlying preference structure.² Ideally, testing the “consistency” of the two data sets would take the form of tests for the equality of parameters estimated separately for the two types of data. The problem is that most data sets lack sufficient variation in both price and quality to fully test for consistency in the responses of participants. Azevedo, Herriges and Kling (2003) test for the consistency of RP and CB trips to wetlands, but are limited to investigating travel cost response parameters (real versus hypothetical). Their data lacked sufficient variation in wetland quality attributes to test for consistency in the associated quality parameters.

Adamowicz *et al.* (1997) also test for consistency between observed and contingent behavior data. They compare the choice of moose hunting sites using observed (RP) trips to stated preferences (SP) in the form of conjoint data.³ They also investigate the effect of perceptions versus objective measures of environmental quality on site demand. The subjective

² This issue is analogous to concern in the contingent valuation literature regarding the incentive compatibility of CV referendum questions.

³ Conjoint CB surveys ask respondents to choose a preferred option from among pairs (or sets) of hypothetical sites, rather reporting than visits to actual sites under hypothetical quality changes.

perceptions of quality are then used as explanatory variables in an $RP_{\text{perceptions}}$ model. An $RP_{\text{objective}}$ model is also developed using objective perceptions of quality as explanatory variables. Both models are pooled in order to test for consistency between actual and CB responses. For each of these pooling models the authors fail to reject the null hypothesis of parameter equality. However, the consistency test for a third model, which pools all three data sets, results in the rejection of parameter equality.

There are two limitations to the Adamowicz *et al.* (1997) study. First, limitations in the actual site quality attributes preclude them from estimating a full set of quality effects for the revealed preference data alone. Second, the contingent behavior data is based on hypothetical sites and attributes. The hypothetical nature of the sites makes the direct comparison (and modeling) of the RP and CB data less straightforward. The advantage of the Iowa Lakes data, in contrast, is that there is ample variation in the water quality attributes and the RP and CB trip information concerns the same set of actual sites.

Finally, two recent studies shed light on the convergent validity issue. Loomis and Richardson (2006) contrast aggregate demand for visits to Rocky Mountain Natural Park between 1987 and 1999 and individual level contingent behavior data concerning anticipated trips under hypothetical climatic conditions. The authors find that the two data sources yield comparable estimates of peak season visitation rates under two alternative climate scenarios.

Whitehead *et al.* (2007) investigate the convergent validity issue in the context of single site count data models combining actual and contingent behavior data on trips to beaches in southern North Carolina. As was the case in Azevedo, Herriges and Kling (2003), the test of convergent validity in Whitehead *et al.* (2007) is restricted to comparing the marginal impact of economic factors (price and income) on recreation demand, without comparing responses to

changing environmental conditions.⁴ They do, however, find statistically significant differences between their RP and SP models in terms of the marginal impacts of both travel cost and income on trip demand, though the RP/SP differences are not substantial.

III. Data and Survey Results

The 2004 Iowa Lakes Survey is the third year survey in a four year study, jointly funded by the Iowa Department of Natural Resources and the USEPA, aimed at understanding recreational lake usage in Iowa and the value placed on water quality in the state. The survey was sent by direct mail in February of 2005 to the 5,206 Iowans who completed the 2003 survey.⁵ The survey collected information on a household's past trip behavior in 2004 and anticipated trips in 2005 under both current and hypothetically improved water quality levels.

The survey itself has two major sections.⁶ The first section (pp 3-7) asks respondents to report how frequently they visited each of 131 lakes in the state during 2004 and how frequently they intend to visit in 2005 under both current conditions and a proposed water quality improvement. In describing both current and hypothetical water quality conditions, a water quality ladder index was used (Figure 1). The top of the water quality ladder, as originally proposed by Carson and Mitchell (1983), stands for the best possible quality of water, while the bottom of the ladder stands for the worst. The lowest level is so polluted that contact with it is dangerous to human health. Water quality that is "boatable" would not harm people who happened to fall into it for a short time while boating or sailing. Water quality that is "fishable" is a higher level of quality than "boatable". Although some kinds of fish can live in boatable

⁴ The authors also compare the welfare implications of single- and multiple-site models as another convergent validity test. They find that the willingness to pay for environmental improvements from their single site models are consistent with those obtained from a multi-site Kuhn-Tucker model, but differ substantially from the WTP implied by a linked participation/site-selection model.

⁵ The 2003 Iowa Lakes survey was mailed to the 4,423 households who completed the 2002 Iowa Lakes survey, plus an additional 3577 Iowa residents selected randomly from among households living in the state.

⁶ A copy of the survey is provided as an appendix to this paper.

water, it is only when water is "fishable" that game fish like bass can live in it. Finally, "swimmable" water is of a high enough quality that it is safe to swim in and ingest in small amounts. In the survey, the water quality ladder is described in detail at the beginning of the section and then pictured page by page on the survey.

The proposed water quality improvement scenario would move all the lakes to at least the swimmable level (7). If current water quality index of a lake is below 7 (swimmable) then the improved water quality is 7. If current water quality of a lake is above or at 7, then water quality is unchanged under the scenario. Under this scenario, the water quality of fifty-two lakes in Iowa would be improved, while seventy-nine lakes would remain unchanged. Color coded numbers, along with the water quality ladder, were used to convey the water quality conditions.

In order to collect information about each household's single day trips for each of the lakes in the survey, three columns were provided in which to indicate actual single day trips in 2004 and anticipated trips in 2005 under current and proposed water quality levels. Figure 2 provides a portion of the spreadsheet used in gathering this information. The first column is for actual number of past trips in 2004 (i.e., "observed trips") and the second column is for anticipated number of trips in 2005 under the current water quality (i.e., "next year trips"). The third and fourth columns show the current water quality conditions and proposed water quality improvement in terms of the water quality ladder. Given the water quality improvement scenario, respondents were asked to indicate how many single day trips they would make to each of the lakes in the last column (i.e., "CB trip").

The second section of the survey (pp 7-10) collects socio-demographic information, including age, gender, education, etc. Further, the second section of the questionnaire asks the details of a household's employment status including the number of work weeks, paid vacations,

work hours per week, either hourly wage or salary, and the work options (e.g., whether individual is free to choose or scheduled to work). These latter data are not used for the current analysis.

Similar to the 2002 and 2003 Iowa Lakes Survey, standard follow-up procedures were used to encourage a high response rate to the survey, including a postcard reminder mailed two weeks after the initial mailing and a second copy of the survey mailed one month later. In addition, survey respondents were provided with a \$10 incentive for completing the survey. A total of 4,242 surveys were returned and recorded.⁷ Allowing for undeliverable surveys, this corresponds to a response rate of 84%. The high response rate is due, in part, to the fact that the sample used for the 2004 survey consisted of last year's survey respondents.

From the 4,242 completed surveys, 2,768 surveys are used in our analysis below. The sample attrition (detailed in Table 1) is due to two factors. First, a number of the survey respondents did not complete all of trip questions (actual and contingent) elicited in the first part of the survey, with the largest gaps occurring for the contingent behavior data under improved water quality conditions. As column 1 of Table 1 indicates, ninety-seven percent of the respondents provided information on their actual trips in 2004 and ninety-two percent provided information about their planned trips in 2005 given current water quality conditions. However, only seventy-one percent of the households completed information regarding their contingent trips to Iowa lakes under the improved water quality conditions. In order to maintain a balanced panel, those observations without complete data for all three trip categories were excluding from the analysis, leaving 2932 complete surveys (just under seventy percent of the original set of respondents). The high item nonresponse rate for the contingent behavior question raises the potential issue of nonresponse bias in the subsequent analysis. To investigate

⁷ An additional 66 surveys were returned completed, but were lost during the data entry process prior to encoding.

this concern, we compared the observable characteristics (e.g., age, income, gender, education, size of household, and actual trips in 2004) for the sample used in the analysis versus those lost due to item non-response. The differences between the two groups were consistently minor.⁸ This does not, of course, eliminate the potential for nonresponse bias. Thus, caution should be used in extrapolating the results of the analysis to the population as a whole.

The second reduction in the sample was due to the elimination of households with trips in excess of 52 per year (i.e., those households averaging more than one trip per week). Our concern with including individuals that report large numbers of trips is that these households consist predominantly of individuals who live in close proximity to a lake.⁹ It is our sense that residents who take a walk along a lake, or pass it on the way to or from work, are purchasing a very different commodity from the family that packs a cooler and dedicates several hours of their day to driving to a lake and enjoying its activities. Our focus is on the latter notion day trips. This exclusion reduces the sample by another 5.5%, leaving a total of 2768 respondents for use in our analysis (or approximately 53% of the households originally mailed the survey).¹⁰

Table 2 provides summary statistics for the three types of trips and for several key socio-economic variables. The average number of observed single day trips in 2004 to all 131 lakes is 6.94, ranging from zero to 52 trips per year. The average numbers of trips anticipated in 2005 under current and the hypothetically changed conditions are 9.18 and 9.42, respectively. Thus, survey respondents expect (or perhaps hope) to take more trips in 2005 regardless of whether or not the water quality will be improved. It is not uncommon in the literature to find

⁸ Results of the comparisons are available from the authors upon request.

⁹ Indeed, the median distance to the primary lake visited in these instances is less than five miles.

¹⁰ It should be noted, however, that the cutoff of 52 choice occasions per year may exclude some day trips, such as those made by retired individuals with more time available for recreational activities. To address this concern, sensitivity analysis was conducted, raising the limit to 95 trips per year. This cutoff reduces the loss of observations by 50 percent and allows for a trip every other day during the six months when recreational lake usage typically occurs in Iowa. While the resulting parameter estimates were, of course, different, the change did not alter the qualitative findings reported below.

such a substantial gap between past trips and anticipated trips (even without changes in conditions). This result emphasizes the importance of eliciting anticipated trips under status quo conditions, so as to better isolate the net impact of hypothetical changes to environmental attributes.

Turning to the socio-demographic characteristics, we find the survey respondents to more likely be older, male, have a higher income, and be more educated than the general Iowa population. Schooling is entered as a dummy variable equaling one if the individual has attended or completed some level of post high school education.

Table 3 summarizes the change total trips to each lake in the 2005 anticipated under the hypothetical water quality improvements relative to those anticipated under current conditions, averaged over lakes with the same initial water quality. As expected, the anticipated number of day trip increases for those lakes with initial water quality is below 7 (i.e., for the lakes that are improving). For example, among the five lakes with an initial water quality index of 4, total trips are anticipated to increase on average by 23.8 trips per lake when the water quality is improved to swimmable (with an index of 7). Similarly, total trips to lakes whose initial water quality is 6 increase on average by 33.2 trips. On the other hand, CB trips decrease on average for those lakes whose initial water quality is at or above 7. These aggregate data in Table 3 do suggest that individuals respond to the hypothetical water quality improvements in the manner we would expect, increasing anticipated trips to the improved lakes and substituting away from the unimproved sites. As the standard deviations indicate, however, each of changes Table 3 is statistically insignificant. In the following section, we develop a repeated mixed logit model to better discern the patterns in the contingent behavior responses.¹¹

¹¹ Since the recreational trip information takes the form of count data, an alternative to the repeated mixed logit modeling approach described below would be to use a system of count regression models. The difficulty here is that, in the current setting, this would involve 393 count equations, three equations for each of the 131 sites. A system of Poisson models, while feasible, would not capture likely correlation among the various counts. Models

IV. Model

Three types of data are used to jointly estimate the recreational demand for lake usage in Iowa and to test hypotheses regarding contingent behavior responses: observed trips in 2004, anticipated trip for 2005 under current water quality, and contingent behavior trips for 2005 under hypothetically improved water quality. Two hypotheses are of interest: one is whether households anticipate changes for their day trips next year (without changing water quality conditions) and the other is whether households respond to the hypothetical water quality improvements in the same way they responded to actual water quality differences across lakes in 2004. The latter hypothesis addresses directly the issue of convergent validity. We include the former hypothesis to emphasize the importance of control for year to year variation in trips and, in particular, for the differences that may exist between historical (i.e., actual trips) and anticipated trips, even without changes in water quality conditions.

The model begins by specifying the conditional utility that household i associates with visiting site j on choice occasion t ($t = 1, \dots, 52$) under scenario s , where $s = 04$ (for 2004 observed trips data), 05 (for 2005 anticipated trips under current water quality conditions), and $05H$ (for 2005 trips under hypothetical conditions). This utility is assumed to depend upon five broad groups of factors:

- the cost of visiting a given site (P_{ij});
- the water quality at the site (Z_{js} and Z_{js}^H);
- a vector site attributes other than water quality (X_j);
- a vector of household characteristics (H_i); and
- a dummy variable used to isolate differences between 2005 and 2004 behavior (D_{5s}).

that do allow for such correlations, such as the SUPREME model and the Multivariate Poisson Lognormal, have typically been restricted to systems with less than five equations.

Each of these variables is described in detail below. The overall structure of the conditional utility is assumed to have the form

$$\begin{aligned}
 U_{ijts} = & V(P_{ij}, Z_{js}, Z_{js}^H, X_j, H_i) + \varepsilon_{ijts} \\
 = & \begin{cases} \kappa' H_i + \varepsilon_{i0ts} & j=0; i=1, \dots, I; t=1, \dots, 52 \\ \left[\alpha_i + \beta_i D_{5s} + \gamma_i' X_j \right] - [\lambda_0 + \lambda' H_i] P_{ij} + \left[(\delta_0 + \delta^{0s} D_{5s}) Z_{js} + \delta^H Z_{js}^H \right] + \varepsilon_{ijts} & j=1, \dots, J; i=1, \dots, I; t=1, \dots, 52. \end{cases}
 \end{aligned} \tag{1}$$

$V_{ijts} \equiv V(P_{ij}, Z_{js}, Z_{js}^H, X_j, H_i)$ is the deterministic component of utility and ε_{ijts} is an error component capturing unobservable determinants of the household's decision, which is assumed to be an *iid* extreme value random variable.¹²

The utility associated with choosing the stay at home option ($j=0$) is assumed to depend upon a vector of socio-demographic characteristics H_i , including the gender of the survey respondent, a dummy variable indicating older adults (i.e., over 60 years of age), a dummy variable as to whether they have completed some post high school education and the household size (i.e., number of members). Summary statistics for these demographic factors are contained in Table 2.

The conditional utility associated with visiting one of the lakes has three primary components, delineated by square brackets in equation (1). The first component

$$C_1 = \alpha_i + \beta_i D_{5s} + \gamma_i' X_j \tag{2}$$

allows for an overall individual specific shift in utility α_i associated with taking trips (relative to staying at home). As Herriges and Phaneuf (2002) note, this induces a substitution structure similar to the traditional nested logit model (nesting all of the trip options in a single nest). The

¹² If the error component ε_{ijts} , which we have assumed to be i.i.d. extreme value random variable, was only random term in the conditional utility function, then the model would reduce to the conventional conditional logit specification. However, as described in detail below, a number of the parameters in the utility function are also assumed to be random, making the ultimate model a repeated mixed logit specification.

second term in this component allows for an overall shift in anticipated trips in 2005, with D_{5s} denoting a dummy variable that = 1 for $s = 05$ and $05H$, and = 0 otherwise. Finally, the conditional utility from visiting site j is assumed to depend upon site characteristics (X_j), including

- the size of the lake, measured in log(acres);
- a dummy variable indicating the presence of a paved boat ramp;
- a dummy variable indicating whether the lake has wake restrictions;
- a dummy variable indicating the presence of handicap facilities; and
- a dummy variable indicating whether or not the lake is part of a state park.

Summary statistics for each of these variables is provided in Table 2.

The second component affecting the utility of household i visiting site j captures the cost of traveling to the site:

$$C_2 = [\lambda_0 + \lambda' H_i] P_{ij} \quad (3)$$

where P_{ij} denotes the travel cost from the household's residence to lake j as calculated using PCMiller. The travel costs are computed allowing for a mileage cost of 25 cents per mile plus the cost of travel time valued at one third of the wage rate. The marginal utility of income (as reflected in the travel cost coefficient) is allowed to vary with the socio-demographic characteristics, with these differences captured by the parameter vector λ .

Finally, the third component in the utility household i receives from visiting site j reflects the impact of site water quality:

$$C_3 = (\delta_0 + \delta^{05} D_{5s}) Z_{js} + \delta^H Z_{js}^H \quad (4)$$

where Z_{js} represents water quality ladder index for lake j under scenario s and Z_{js}^H denotes the difference between baseline water quality and the hypothetical water quality under scenario $s=05H$. Thus $Z_{js}^H = 0$ for $s = 04$ and 05 , while taking nonnegative values for the contingent

behavior trip ($s = 05H$). The parameter δ_0 denotes the baseline response to changes in the water quality.¹³ δ^{05} captures shifts in the marginal response to water quality between 2004 and 2005. The focus of our analysis, however, is on δ^H , which captures the *additional* marginal response to a hypothetical improvement of water quality.

To further clarify the role of the parameters in this final component, consider an improvement in water quality of ΔZ to site j . If this is a real change in water quality in 2004, it would alter site j 's utility by $\delta_0 \Delta Z$. In contrast, the same (actual) change in water quality in 2005 would alter utility by $(\delta_0 + \delta^{05}) \Delta Z$. Finally, if this change in 2005 was hypothetical in nature, then the utility would be altered by $(\delta_0 + \delta^{05} + \delta^H) \Delta Z$.

Notice that the parameters α_i , β_i , and γ_i are allowed to vary across individuals, allowing for heterogeneity of preferences and correlation in the utilities of individuals across choice occasions.¹⁴ Specifically, these parameters are assumed to be distributed randomly across individuals in the population. The random parameter α_i was introduced by including dummy variable R_j which equals one for all of the recreation alternatives ($j = 1, \dots, J$) and equals zero for the stay at home option ($j = 0$), following Herriges and Phaneuf (2002).

Similarly, β_i was introduced by including $R_j \times D_{5s}$ which equals zero for the actual trips in 2004

¹³ At the suggestion of a reviewer, we also considered possible interaction effects between Z_{js} and household demographic characteristics. In general, these interactions were statistically insignificant, though we did find that households with greater schooling were more responsive to the water quality conditions. We have kept with the simpler base model here to simplify the exposition.

¹⁴ The choice of which parameters to vary across individuals (i.e., model as random parameters) is, to some extent, a matter of judgment. The α_i term's random structure mimics the classic nested logit model frequently used in the literature. Variations in preferences for site attributes, such as wake restrictions and boat ramps, have been found in a number of previous studies (e.g., Train, 1998, and Egan *et al.*, 2008) and are incorporated here by allowing γ_i to be random. These differences are typically attributed to differences in household preferences for different types of recreational opportunities (e.g., power boating versus canoeing) and differences in the desire for more natural or more developed settings. In terms of the price coefficients, it has become standard practice in the recreation demand literature to restrict these to be fixed, simplifying the implied marginal willingness to pay for a site attribute to having the same distribution as the associated parameter. Finally, we have left the marginal impact of site water quality as a fixed function of observable individual attributes. This simplifies the comparison across the three scenarios being considered.

and stay at home option while it equals one for all of the recreation sites for anticipated trips in 2005.

The random parameters α_i , β_i , and γ_i can be viewed as sum of their respective means ($\bar{\alpha}$, $\bar{\beta}$, and $\bar{\gamma}$) and individual deviations from these means (τ_i , ρ_i , and ϕ_i), allowing for variation in an individual's tastes relative to the average tastes in the population (Train, 1998). Therefore, we can rewrite the utility function in (1) as

$$U_{ijts} = \begin{cases} \kappa' H_i + \eta_{i0ts} \\ \left[\bar{\alpha} + \bar{\beta} D_{5s} + \bar{\gamma} X_j \right] - [\lambda_0 + \lambda' H_i] P_{ij} + \left[(\delta_0 + \delta^{05} D_{5s}) Z_{js} + \delta^H Z_{js}^H \right] + \eta_{ijts} \end{cases} \quad (5)$$

$i=1, \dots, I, j=1, \dots, J, t=1, \dots, 52.$

where the unobservable portion of utility is given by

$$\eta_{ijts} = \begin{cases} \varepsilon_{i0ts}, & i=1, \dots, N \\ \phi_i + \rho_i D_{5s} + \tau_i' X_j + \varepsilon_{ijts}, & j=1, \dots, J, i=1, \dots, I, t=1, \dots, 52. \end{cases} \quad (6)$$

These unobservable components of utility induce correlation in the observed choices made by households over sites, choice occasions and scenarios. For example, a household with a large negative deviation from the mean of α_i will be more likely to choose the stay-at-home option on each choice occasion, the ϕ_i capturing in this case some unobserved attribute of the household causing them to prefer staying at home (e.g., they cannot swim or do not own a boat). In a similar fashion, the random component associated with dummy variable D_{5s} (i.e., ρ_i) captures heterogeneity across households in how they anticipate their trip taking to change between 2004 and 2005, due to factors such as changing health conditions and income that are unobserved by the analyst. As Train (2003, p. 145), one of the advantages of the mixed logit structure used here is that it "...does not exhibit independence of irrelevant alternatives (IIA) or the restrictive substitution patterns of logit."

Given that the ε_{ijts} 's are assumed to be *iid* extreme value, the resulting model, conditional on the random parameters α_i , β_i , and γ_i , corresponds to McFadden and Train's (2000) mixed logit framework. A mixed logit model is defined as the integration of the logit formula over the distribution of unobserved random parameters (Revelt and Train, 1998). Let the vector of random parameters in the model defined above denoted by $\omega_i = (\alpha_i, \beta_i, \gamma_i)$ and let $\xi = (\kappa, \lambda_0, \lambda, \delta_0, \delta^{05}, \delta^H)$ denote the fixed parameters. If the random parameters, ω_i , were known, then the probability of observing household i choosing alternative j on choice occasion t for scenario s would follow the standard logit form

$$L_{ijts}(\omega_i, \xi) = \frac{\exp(V_{ijts}(\omega_i, \xi))}{\sum_{k=0}^J \exp[V_{ikts}(\omega_i, \xi)]}. \quad (7)$$

Since V_{ijts} is not a function of t , the overall contribution of household i to the likelihood function would be

$$L_i(\omega_i, \xi) = \prod_s \prod_j L_{ijs}(\omega_i, \xi)^{n_{ijs}},$$

where n_{ijs} denotes the number of trips by household i to site j under scenario s and $L_{ijs}(\omega_i, \xi)$ denotes the common value of $L_{ijts}(\omega_i, \xi)$ across all t . Since the ω_i is unknown, the corresponding unconditional probability, $P_i(\theta, \xi)$, is obtained by integrating over an assumed probability density function for the ω_i 's. The unconditional probability is now a function of θ , where θ represents the estimated moments of the random parameters.¹⁵ This Repeated Mixed Logit (or RXL) model assumes the random parameters are *iid* distributed over the households

¹⁵ In the current model, $\theta = (\bar{\alpha}, \bar{\beta}, \bar{\gamma}, \sigma_{\gamma 1}, \dots, \sigma_{\gamma k}, \sigma_{\alpha}, \sigma_{\beta})$.

so that

$$P_i(\theta, \xi) = \int L_i(\omega_i, \xi) f(\omega_i | \theta) d\nu. \quad (5)$$

No closed form solution exists for this unconditional probability and therefore simulation is required for the maximum likelihood estimates of θ and ξ .¹⁶ One thing to note is that since household i appears three times in the model, the same draws of the random parameter vector are used for three repeated choices. This specification does not lead to perfect error correlations because the independent extreme value term ε_{ijts} still enters the utilities for each choice.

Given the model in equation (1), there are three principle hypotheses of interest. The first hypothesis is whether or not individuals respond differently to hypothetical water quality improvement than they do to actual water quality differences across lakes, i.e., $H_0^1 : \delta^H = 0$. The second hypothesis is whether or not individuals anticipate changes in their overall trips between 2004 and 2005. This hypothesis can be written as $H_0^2 : \beta_i = \delta^{05} = 0$. The last hypothesis is the joint hypothesis; i.e., $H_0^3 : \beta_i = \delta^{05} = \delta^H = 0$.

V. Estimation Result

A total of three models are estimated: the full model and two reduced models corresponding to Hypothesis H_0^2 (Model R₁) and Hypothesis H_0^3 (Model R₂) respectively. The resulting parameter estimates, along with robust standard errors, are presented in four Tables (4a through 4d). Table 4a lists those parameters impacting the household's decision to stay at home on a given choice occasion, versus choosing to take a recreational trip to any one of the 131 lakes in

¹⁶ Train (2003) describes simulation methods for use with mixed logit models, and in particular the maximum simulated likelihood estimator that we employ. Software written in GAUSS to estimate mixed logit models is available from Train's home page at <http://elsa.berkeley.edu/~train>. For the analysis in this paper, we use a modified version of Train's code that takes advantage of the fact that site characteristics do not change across choice occasions, greatly speeding up the estimation routine and reducing the data storage requirements relative to Train's standard panel data code.

the choice set. The estimated coefficients are, with the exception of household size, statistically significant at a 5% level or less. The propensity to stay at home is found to be higher for older adults, but lower for males, those with a higher education level, and households with more members. These results are stable over the three specifications.

Turning to the trip utilities, Table 4b focuses on those parameters in component 1 (i.e., equation (2)) of the utility that a household receives from visiting site j . The mean of α_i , associated with the trip dummy variable, is negative and statistically significant, indicating that *on average* respondents receive greater utility from the stay-at-home option. This is consistent with our expectations since the average number of trips is just under 7 out of a possible 52 choice occasions. The large size of α_i (in absolute value) is necessary to offset the fact that there are 131 alternatives involving a trip, with only one corresponding to staying at home. At the same time, the mean of β_i is positive and statistically significant, indicating that on average respondents anticipate taking more trips in 2005 regardless of water quality.¹⁷

Turning to the site attributes in Table 4b, we find that the mean coefficient for each attribute is positive, as anticipated, with the average household preferring lakes in state parks and larger lakes, as well as those with paved boat ramps, handicap facilities, and wake restrictions.¹⁸ Notice, however, the large dispersion associated with each of these parameters, indicating considerable heterogeneity in terms of individual preferences for these attributes.¹⁹ For example, the large estimated dispersion on the “wake” dummy variable (1.020) indicates

¹⁷ The dispersion estimated for β_i is, however, statistically insignificant, suggesting that one might reasonably constrain this parameter to being fixed, rather than random.

¹⁸ It should be kept in mind that both the handicap facilities and the state park designations may be serving as proxies for a broader interest in facilities at the site.

¹⁹ The term “dispersion” here refers to the standard error of the random parameter’s distribution. Thus, if the coefficient on the wake dummy variable is assumed to be normally distribution, with $\beta_{wake,i} \sim N(\bar{\beta}_{wake}, \sigma_{wake}^2)$, then the dispersion of this random parameter is σ_{wake} . The use of the term “dispersion” is aimed at avoiding confusion between the standard error for the estimator of $\bar{\beta}_{wake}$ and the estimate of the variability of the random parameter.

that a large percentage (just under forty percent) of the estimated distribution for the random parameter $\beta_{wake,i}$ is negative. This seems particularly appropriate given the potentially conflicting interests of anglers and recreational boaters. Anglers would possibly prefer “no wake” lakes, while recreational boaters would prefer lakes that allow wakes.

Turning to Table 4c, we present here the travel cost parameters. As expected, travel cost has a negative coefficient that is statistically significant at a 1% level and stable across the three specifications. In general, the price coefficient is larger (in absolute value) for women, older households, those with more family members, while it is smaller for those with a higher education level. These results change little over the three model specifications.

Finally, we turn to key parameters of our analysis, listed in Table 4d. These parameters reflect the response of households to water quality attributes, both real and hypothetical, as summarized by the water quality index, Z . Focusing on the full model, we find that the marginal response to the water quality ladder of a lake (δ_0) is 0.142, which is statistically significant at a 1% level. Thus, households tend to choose those lakes that, all else equal, have higher level of water quality. The coefficient δ^{05} indicates that the anticipated response to water quality in 2005 is slightly (though insignificantly) larger, with the marginal response to water quality increasing by 0.011. Finally, the response to a hypothetical change in water quality is found to be significantly less than the response to a corresponding real change. Specifically, δ^H is estimated to be -0.041, which is statistically significant at a 5% level. The net response to a hypothetical marginal change in water quality in 2005 is then $(0.142 + 0.011 - 0.041 = 0.112)$.

Turning to our three hypothesis, the results in Table 4d lead us to reject all three hypotheses. In the current application, households do not respond the same to hypothetical water quality improvements as they do to actual water quality differences across the lakes. With δ^H being statistically significant, we reject the hypothesis $H_0^1 : \delta^H = 0$. We also reject the

hypothesis $H_0^2 : \beta_i = \delta^{05} = 0$; i.e., that there is no difference in household preferences between 2004 and 2005.²⁰ Examination of Table 4d, however, suggests that these differences are not due to changes in household attitudes towards water quality (since δ^{05} is insignificant), but rather an overall shift between actual and anticipated trips (as reflected in β_i). Finally, we reject the joint hypothesis $H_0^3 : \beta_i = \delta^{05} = \delta^H = 0$.

VI. Welfare Estimation

The results of the previous section indicate that individuals respond somewhat less to the hypothetical water quality improvements than to changes in actual water conditions. In this section, the impacts of these differences are illustrated by contrasting the implied compensating variation (CV) and trip changes predicted for a key lake in the state (Storm Lake) based on one of three assumed models:

- Model 1 - The unconstrained model of equation 1 assuming the changes are actual: This corresponds to setting $Z_{js}^H = 0$ in equation 1 for both the baseline and changed conditions;
- Model 2 – The unconstrained model of equation 1 assuming the changes are hypothetical: This corresponds to setting $Z_{js}^H = 0$ in equation 1 under baseline conditions, but setting $Z_{js}^H = \Delta Z$ for Storm Lake under the changed conditions, where ΔZ denotes the proposed water quality improvement; and
- Model 3 – The constrained model R_2 : This corresponds to ignoring possible differences between households responses to actual and hypothetical water quality conditions at the estimation stage of the analysis.

Models 1 and 2 both assume that convergent validity does not hold and are used to contrast the

²⁰ The test in this case is based on a likelihood ratio test, with a chi-squared test statistic of 14.24 with 2 degrees of freedom. This is clearly rejected with a 1% significance level.

impact of actual versus hypothetical changes in water quality. Model 3 assumes that convergent validity does hold. The water quality improvement considered is a movement of Storm Lake's water quality index from its current level of 5, which is "fishable," to a level of 7, which "swimmable".

Formally, let²¹

$$\begin{aligned}
 V_{ijt} &= V(Z_j, Z_j^H; \theta_i) \\
 &= \left\{ \kappa' H_i \right. \\
 &\quad \left. \left[\left[\alpha_i + \beta_i + \gamma_i' X_j \right] - \left[\lambda_0 + \lambda' H_i \right] P_{ij} + \left[\left(\delta_0 + \delta^{05} \right) Z_j + \delta^H Z_j^H \right] \right] \right\} \\
 &\quad i=1, \dots, I, j=1, \dots, J, t=1, \dots, 52
 \end{aligned} \tag{8}$$

denote the deterministic portion of consumer preferences estimated for 2005 *conditional* on the random parameter vector, $\theta_i = (\alpha_i, \beta_i, \gamma_i)'$. For model 1, the corresponding conditional compensating variation associated with the proposed scenario is given by

$$CV_i^1(\theta_i) = \frac{1}{\lambda} \left\{ \ln \left(\sum_{j=0}^J \exp \left[V(Z_j^1, 0; \theta_i) \right] \right) - \ln \left(\sum_{j=0}^J \exp \left[V(Z_j^0, 0; \theta_i) \right] \right) \right\}, \tag{9}$$

where Z_j^0 and Z_j^1 denote the baseline and changed water quality conditions for site j , respectively. In contrast, for model 2, the conditional compensating variation is given by

$$CV_i^2(\theta_i) = \frac{1}{\lambda} \left\{ \ln \left(\sum_{j=0}^J \exp \left[V(Z_j^1, Z_j^{H1}; \theta_i) \right] \right) - \ln \left(\sum_{j=0}^J \exp \left[V(Z_j^0, 0; \theta_i) \right] \right) \right\}, \tag{10}$$

where Z_j^{H1} denotes the hypothetical change in the water quality condition for site j . Finally, for model 3, we have

²¹ We suppress the price and socio-demographic variables here to simplify notation, since they are assumed to remain constant before and after the water quality changes.

$$CV_i^3(\theta_i) = \frac{1}{\lambda} \left\{ \ln \left(\sum_{j=0}^J \exp \left[\tilde{V}(Z_j^1; \theta_i) \right] \right) - \ln \left(\sum_{j=0}^J \exp \left[\tilde{V}(Z_j^0; \theta_i) \right] \right) \right\}, \quad (11)$$

where

$$\tilde{V}(Z_j; \theta_i) = \begin{cases} \kappa' H_i \\ \left[\alpha_i + \gamma_i' X_j \right] - [\lambda_0 + \lambda' H_i] P_{ij} + \delta_0 Z_j \end{cases} \quad i=1, \dots, I, j=1, \dots, J, t=1, \dots, 52. \quad (12)$$

For each model, the unconditional compensating variation does not have a closed form, but can be simulated using

$$CV_i^m = \frac{1}{R} \sum_{r=1}^R CV_i^m(\theta_i^r), \quad (7)$$

where R is the number of draws and θ_i^r represents draw from the estimated distribution of θ_i .

In our application, we use $R=250$.

The resulting welfare estimates are provided in Table 5, along with the average change in trips to Storm resulting from the proposed water quality improvements.²² The average compensating variation per household for an actual water quality improvement (i.e., using model 1) is \$1.71, but the CV is substantially lower for a comparable hypothetical change (i.e., using model 2), at \$1.20 per household.²³ The thirty percent reduction in welfare reflects the lower response to hypothetical water quality improvements relative to the response to actual water quality changes. Ignoring the distinction between hypothetical and actual water quality differences (as is implied by model 3) yields a welfare estimate between these two figures.

²² Standard errors for both the CV and trip changes are reported in parentheses. These are based on the use of 500 draws from the asymptotic distribution of the parameter estimates, recalculating the CV and trip figures for each draw and computing the standard deviation in the mean CV and trip figures across the draws.

²³ While these welfare impacts are relatively small, they are each statistically significant. Moreover, the proposed change reflects improvements to a single site that is not near the state's major population centers. The point of this exercise, however, is not to value the specific policy so much as to contrast the implications of divergences between actual and hypothetical responses to water quality obtained in our econometric analysis.

Similar results emerge for the implied trip changes to Storm Lake. An actual improvement in water quality to swimmable would induce an increase of 0.065 trips per household, roughly forty percent larger than the 0.046 trips per household implied for a comparable hypothetical change. The changes obtained using model 3 (i.e., ignoring the divergence between the marginal response to actual versus hypothetical changes) are once more between those implied by models 1 and 2, though definitely closer to those of model 1.

VII. Conclusion

The use of contingent behavior data to augment observed recreational usage patterns has become increasingly common, both as a means to explore the impact of environmental improvements beyond the range of observed conditions and as a way of improving the precision of estimated preference parameters. However, there has been little evidence to date as to whether households respond to these hypothetical quality changes in the same way in which they respond to actual conditions. The goal of this paper has been to partially fill this gap using data from the Iowa Lakes Project. Unlike many studies, the Iowa Lakes project provides a unique opportunity in which there already exists a wide range of environmental conditions, allowing us to characterize household response to these conditions. Moreover, data from the 2004 survey provides information on anticipated trip patterns under both baseline and hypothetical water quality conditions.

Using the Iowa Lakes data, we are able to test for convergent validity between the actual response to water quality conditions and hypothetical responses to changes in those conditions. Our results reject the convergent validity of these two data sources, with the marginal utility of hypothetical water quality improvements roughly two-thirds the marginal utility perceived from actual water quality differences across lakes. In the current setting, of course, this divergence is

not a problem, as there is sufficient variation in the actual water quality conditions to estimate the marginal utility for *both* actual and hypothetical water quality changes. The problem in most settings, however, is that such variation does not typically exist. Indeed, this is often the primary reason for introducing contingent behavior data to the analysis in the first place. In these cases, the analyst is forced to rely upon the response to hypothetical changes to environment conditions to infer actual responses. Our results suggest that this can be a potentially misleading approach, though further research is needed to determine the extent to which our results hold up in different settings.

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Figure 1 Water Quality Ladder

Water Quality Ladder

Figure 2. Partial Image of Trip Spreadsheet

Name of Lake (County)	Number of Visits		Water Quality		Anticipated Single Day Trips with the higher Proposed Water Quality
	Actual 2004	Anticipated 2005	Current	Proposed	
Lake Ahquabi (Warren)	# ___(trips)	# ___(trips)	7	7	# ___(trips)
Lake Anita (Cass)	# ___(trips)	# ___(trips)	8	8	# ___(trips)
Arbor Lake (Poweshiek)	# ___(trips)	# ___(trips)	6	7	# ___(trips)
Arrowhead Lake (Pottawattamie)	# ___(trips)	# ___(trips)	5	7	# ___(trips)
Arrowhead Pond (Sac)	# ___(trips)	# ___(trips)	9	9	# ___(trips)
Avenue of the Saints Lake (Bremer)	# ___(trips)	# ___(trips)	6	7	# ___(trips)
Badger Creek Lake (Madison)	# ___(trips)	# ___(trips)	4	7	# ___(trips)
Badger Lake (Webster)	# ___(trips)	# ___(trips)	6	7	# ___(trips)
Beaver Lake (Dallas)	# ___(trips)	# ___(trips)	5	7	# ___(trips)
Beed's Lake (Franklin)	# ___(trips)	# ___(trips)	5	7	# ___(trips)
Big Creek Lake (Polk)	# ___(trips)	# ___(trips)	7	7	# ___(trips)
Big Spirit Lake (Dickinson)	# ___(trips)	# ___(trips)	8	8	# ___(trips)
Black Hawk Lake (Sac)	# ___(trips)	# ___(trips)	7	7	# ___(trips)
Blue Lake (Monona)	# ___(trips)	# ___(trips)	7	7	# ___(trips)
Bob White Lake (Wayne)	# ___(trips)	# ___(trips)	5	7	# ___(trips)
Briggs Woods Lake (Hamilton)	# ___(trips)	# ___(trips)	5	7	# ___(trips)

Water Quality Ladder

Best possible water quality

10 Safe to drink

9

8

7 Safe for swimming

6

5 Game fish like bass can live in it

4

3

2 Okay for boating

1

0 Dangerously polluted

Worst possible water quality

Table 1. Survey Sample

	Item Respondents ^a	Trips > 52 ^b	Total
2004 (Observed) Day Trips	4099 (97%)	111 [2.7%]	3988 (94%)
2005 Anticipated Day Trips	3885 (92%)	153 [3.9%]	3732 (88%)
2005 CB Day Trips	3035 (71%)	139 [4.4%]	2896 (68%)
Total	2932 (69%)	164 [5.5]	2768 (65%)

^aFigures in parentheses indicate the percentages of the returned and encoded surveys (4242).

^bFigures in square brackets represent percentages of corresponding item respondents.

Table 2. Summary Statistics

	Mean	Std. Dev	Minimum	Maximum
2004 (Observed) Day Trips ^a	6.94	9.19	0	52
2005 Anticipated Day Trips ^a	9.18	10.84	0	52
2005 CB Day Trips ^a	9.42	11.36	0	52
Income ^a	\$59,755	\$37,550	\$7,500	\$200,000
Male ^a	0.66	0.47	0	1
Older Adult ^a	0.66	0.47	0	1
School ^a	0.69	0.46	0	1
Household Size ^a	2.52	1.27	1	12
Log(Acres) ^b	2.08	0.73	1	4.28
Boat Ramp Dummy Variable ^b	0.86	0.35	0	1
Wake Restrictions Dummy ^b	0.67	0.47	0	1
Handicap Facilities Dummy ^b	0.39	0.49	0	1
State Park Dummy Variable ^b	0.39	0.49	0	1

^a Sample Size = 2,768 households

^b Sample Size = 131 lakes.

Table 3. Total Trip Changes by Lake and Initial Water Quality^a

Initial Water Quality	Proposed Water Quality		
	7	8	9
3	20.0 (1; NA)		
4	23.8 (5; 20.7)		
5	21.1 (25; 51.9)		
6	33.2 (21; 51.9)		
7	-7.3 (32; 21.2)		
8		-10.6 (43; 26.6)	
9			-1.3 (4; 7.1)

^a Number of lakes and standard deviations in parentheses

Table 4a. Parameter Estimates – Stay at Home Utility (Robust Standard Errors in Parentheses)

	Full Model	Model R ₁	Model R ₂
Male	-1.071*** (0.174)	-1.069*** (0.256)	-1.072*** (0.251)
Age	1.094*** (0.191)	1.494*** (0.223)	1.505*** (0.222)
School	-0.781*** (0.186)	-0.401** (0.201)	-0.397** (0.197)
Household Size	-0.145** (0.060)	-0.125* (0.076)	-0.122* (0.074)

*, **, and *** are used to denote significance at the 10, 5 and 1 percent levels, respectively.

Table 4b. Parameter Estimates – Trip Utility Component 1 (Robust Standard Errors in Parentheses)

	Full Model	Model R ₁	Model R ₂
Mean Estimate for Random Coefficient			
α_i	-11.702*** (0.271)	-10.956*** (0.325)	-10.949*** (0.322)
β_i	0.398*** (0.139)		
Log (Acre)	0.367*** (0.010)	0.363*** (0.010)	0.363*** (0.010)
Ramp	0.918*** (0.083)	0.773*** (0.073)	0.774*** (0.072)
Facility	0.225*** (0.042)	0.212*** (0.037)	0.212*** (0.038)
State Park	0.592*** (0.039)	0.650*** (0.041)	0.651*** (0.043)
Wake	0.263*** (0.035)	0.267*** (0.032)	0.263*** (0.032)
Dispersion Estimate for Random Coefficient			
α_i	2.291*** (0.0472)	2.215*** (0.052)	2.216*** (0.054)
β_i	0.083 (0.072)		
Log (Acre)	0.320*** (0.014)	0.312*** (0.012)	0.312*** (0.012)
Ramp	1.767*** (0.092)	1.509*** (0.090)	1.509*** (0.086)
Facility	1.060*** (0.054)	1.142*** (0.052)	1.141*** (0.051)
State Park	1.086*** (0.052)	1.091*** (0.044)	1.092*** (0.047)
Wake	1.020*** (0.044)	0.983*** (0.052)	0.983*** (0.054)

Table 4c. – Trip Utility Component 2 (Robust Standard Errors in Parentheses)

	Full Model	Model R ₁	Model R ₂
Price	-0.0434*** (0.0022)	-0.0446*** (0.0022)	-0.0446*** (0.0022)
Price x Male	0.00443*** (0.00144)	0.00446*** (0.00138)	0.00445*** (0.00138)
Price x Age	-0.00579*** (0.00163)	-0.00592*** (0.00158)	-0.00591*** (0.00158)
Price x School	0.00654*** (0.00156)	0.00680*** (0.00158)	0.00680*** (0.00157)
Price x Household Size	-0.00040 (0.00049)	-0.00012 (0.00046)	-0.00012 (0.00046)

Table 4d. Parameter Estimates – Trip Utility Component 3 (Robust Standard Errors in Parentheses)

	Full Model	Model R ₁	Model R ₂
Z _s (δ^0)	0.142*** (0.016)	0.144*** (0.010)	0.146*** (0.010)
Z _s x D05 (δ^{05})	0.0110 (0.0208)		
Z _H (δ^H)	-0.0413* (0.0220)	-0.0317* (0.0218)	
χ^2		14.24 (3 df)	26.9 (4 df)

Robust standard errors in parentheses.

Table 5. Welfare Estimates

	Model 1	Model 2	Model 3
Average CV Per Household (\$'s)	1.71 (0.16)	1.20 (0.30)	1.63 (0.18)
Predicted Change in Trips to Storm Lake	0.065 (0.007)	0.046 (0.012)	0.062 (0.006)

Appendix: The Iowa Lakes Survey 2004

Center for Agricultural and Rural Development
Resource and Environmental Policy Division

IOWA STATE UNIVERSITY
DEPARTMENT OF ECONOMICS

In order to make sound decisions concerning the future of Iowa lakes, it is important to understand how the lakes are used, as well as what factors influence your selection of lakes to visit. The answers you give to the questions in this survey are very important. Even if you have not visited any lakes in Iowa, please complete and return the questionnaire. It is critical to understand the characteristics and views of both those who use and those who do not use the lakes.

In this first section, we would like to find out which of the lakes in the enclosed map you visited in 2004 and how your lake visits might change in the future with changes in lake water quality.

1. Please indicate in the first column how often in 2004 you or other members of your household visited each of the lakes listed on the following pages for a single day trip. In this questionnaire, we will be asking you detailed information only about your single day trips (and not overnight trips). If you did not visit any lake in Iowa in 2004, please check this box.

☐ **I did not visit any lakes in Iowa in 2004.**

If you took overnight trips to Iowa lakes in 2004 please check this box

☐ **I took one or more overnight trips to lakes in Iowa in 2004.**

2. Please indicate in the second column how many single day trips you plan to make to each of the lakes in 2005. If you do not plan to visit any lakes in Iowa in 2005, please check this box.

☐ **I do not plan to visit any lakes in Iowa in 2005.**

3. There are currently efforts underway to improve the water quality of Iowa's lakes. We are interested in knowing how these changes might impact your single day trips to lakes. One way of thinking about water quality is to use a ladder like the one shown below. The top of the water quality ladder stands for the best possible quality of water, and the bottom of the ladder stands for the worst. On the ladder you can see the different levels of water quality.

For example: The lowest level is so polluted that it has oil, raw sewage, and/or other things in it like trash; it has almost no plant or animal life, smells bad, and contact with it is dangerous to human health. Water quality that is "boatable" would not harm you if you happened to fall into it for a short time while boating or sailing. Water quality that is "fishable" is a higher level of quality than "boatable." Although some kinds of fish can live in boatable water, it is only when water is "fishable" that game fish like bass can live in it. Finally, "swimmable" water is of a high enough quality that it is safe to swim in and ingest in small amounts.

For each of the lakes below, we have indicated the current water quality conditions in terms of the water quality ladder. For example, Arbor Lake in Powershiek County is currently rated as a 6 on the water quality ladder. This is above the minimum for fishable, but below the swimmable level. Badger Creek Lake in Madison county, on the other hand, has a current water quality level of 4, which is okay for boating, but not fishable. In the last column of the table, we would like you to indicate how many single day trips you would make to each of the lakes given all of the lakes were improved to at least swimmable (7). Notice that many lakes are already at or above the swimmable level. Please keep in mind that you may choose to take fewer trips to some lakes, while taking more trips to others. If you would not plan to take any trips to Iowa lakes, even given the water quality improvements, please check the following box:

☐ **I would not plan to visit any lakes in Iowa in 2005 even if the water quality improved as indicated.**

Iowa Lakes Survey / 3

Name of Lake (County)	Number of Visits		Water Quality		Anticipated Single Day Trips with the higher Proposed Water Quality
	Actual 2004	Anticipated 2005	Current	Proposed	Water Quality
Lake Ahquabi (Warren)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Lake Anita (Cass)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Arbor Lake (Poweshiek)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Arrowhead Lake (Pottawattamie)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Arrowhead Pond (Sac)	# ____ (trips)	# ____ (trips)	9	9	# ____ (trips)
Avenue of the Saints Lake (Bremer)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Badger Creek Lake (Madison)	# ____ (trips)	# ____ (trips)	4	7	# ____ (trips)
Badger Lake (Webster)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Beaver Lake (Dallas)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Beed's Lake (Franklin)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Big Creek Lake (Polk)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Big Spirit Lake (Dickinson)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Black Hawk Lake (Sac)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Blue Lake (Monona)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Bob White Lake (Wayne)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Briggs Woods Lake (Hamilton)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Brown's Lake (Woodbury)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Brushy Creek Lake (Webster)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Carter Lake (Pottawattamie)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Casey Lake (aka Hickory Hills) (Tama)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Center Lake (Dickinson)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Central Park Lake (Jones)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Clear Lake (Cerro Gordo)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Cold Springs Lake (Cass)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Coralville Lake (Johnson)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Lake Cornelia (Wright)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Crawford Creek Impoundment (Ida)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Crystal Lake (Hancock)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Dale Maffitt Lake (Madison)	# ____ (trips)	# ____ (trips)	9	9	# ____ (trips)
Lake Darling (Washington)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
DeSoto Bend Lake (Harrison)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Diamond Lake (Poweshiek)	# ____ (trips)	# ____ (trips)	4	7	# ____ (trips)
Dog Creek (Lake) (O'Brien)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Don Williams Lake (Boone)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
East Lake (Osceola) (Clarke)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
East Okoboji Lake (Dickinson)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Easter Lake (Polk)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Eldred Sherwood Lake (Hancock)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Five Island Lake (Palo Alto)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Fogle Lake (Ringgold)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Lake Geode (Henry)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
George Wyth Lake (Black Hawk)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Green Belt Lake (Black Hawk)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)

Water Quality Ladder	
Best possible water quality	
10	
9	
8	
7	
6	
5	
4	
3	
2	
1	
0	
Worst possible water quality	
Safe to drink	
Safe for swimming	
Game fish like bass can live in it	
Okay for boating	
Dangerously polluted	

Water Quality Ladder

Name of Lake (County)	Number of Visits		Water Quality		Anticipated Single Day Trips with the higher Proposed Water Quality
	Actual 2004	Anticipated 2005	Current	Proposed	
Green Castle Lake (Marshall)	# (trips)	# (trips)	7	7	# (trips)
Green Valley Lake (Union)	# (trips)	# (trips)	8	8	# (trips)
Greenfield Lake (Adair)	# (trips)	# (trips)	8	8	# (trips)
Hannen Lake (Benton)	# (trips)	# (trips)	8	8	# (trips)
Hawthorn Lake (aka Barnes City) (Mahaska)	# (trips)	# (trips)	8	8	# (trips)
Lake Hendricks (Howard)	# (trips)	# (trips)	5	7	# (trips)
Hickory Grove Lake (Story)	# (trips)	# (trips)	7	7	# (trips)
Hooper Area Pond (Warren)	# (trips)	# (trips)	8	8	# (trips)
Lake Icaria (Adams)	# (trips)	# (trips)	7	7	# (trips)
Indian Lake (Van Buren)	# (trips)	# (trips)	7	7	# (trips)
Ingham Lake (Emmet)	# (trips)	# (trips)	6	7	# (trips)
Lake Iowa (Iowa)	# (trips)	# (trips)	8	8	# (trips)
Kent Park Lake (Johnson)	# (trips)	# (trips)	8	8	# (trips)
Lake Keomah (Mahaska)	# (trips)	# (trips)	5	7	# (trips)
Lacey Keosauqua Park Lake (Van Buren)	# (trips)	# (trips)	9	9	# (trips)
Lake of the Hills (Scott)	# (trips)	# (trips)	7	7	# (trips)
Lake of Three Fires (Taylor)	# (trips)	# (trips)	3	7	# (trips)
Little River (Decatur)	# (trips)	# (trips)	8	8	# (trips)
Little Sioux Park Lake (Woodbury)	# (trips)	# (trips)	8	8	# (trips)
Little Spirit Lake (Dickinson)	# (trips)	# (trips)	6	7	# (trips)
Little Wall Lake (Hamilton)	# (trips)	# (trips)	4	7	# (trips)
Littlefield Lake (Audubon)	# (trips)	# (trips)	5	7	# (trips)
Lost Island Lake (Palo Alto)	# (trips)	# (trips)	7	7	# (trips)
Lower Gar Lake (Dickinson)	# (trips)	# (trips)	5	7	# (trips)
Lower Pine Lake (Hardin)	# (trips)	# (trips)	5	7	# (trips)
Lake Manawa (Pottawattamie)	# (trips)	# (trips)	6	7	# (trips)
Manteno Lake (Shelby)	# (trips)	# (trips)	7	7	# (trips)
Lake Macbride (Johnson)	# (trips)	# (trips)	8	8	# (trips)
Mariposa Lake (Jasper)	# (trips)	# (trips)	5	7	# (trips)
Meadow Lake (Adair)	# (trips)	# (trips)	7	7	# (trips)
Lake Meyer (Winneshek)	# (trips)	# (trips)	7	7	# (trips)
Meyers Lake (Black Hawk)	# (trips)	# (trips)	8	8	# (trips)
Lake Miami (Monroe)	# (trips)	# (trips)	7	7	# (trips)
Mill Creek (Lake) (O'Brien)	# (trips)	# (trips)	8	8	# (trips)
Lake Minnewashta (Dickinson)	# (trips)	# (trips)	7	7	# (trips)
Mitchell Lake (Black Hawk)	# (trips)	# (trips)	7	7	# (trips)
Moorhead Lake (Ida)	# (trips)	# (trips)	8	8	# (trips)
Mormon Trail Lake (Adair)	# (trips)	# (trips)	8	8	# (trips)
Nelson Park Lake (Crawford)	# (trips)	# (trips)	8	8	# (trips)
Nine Eagles Lake (Decatur)	# (trips)	# (trips)	8	8	# (trips)
North Twin Lake (Calhoun)	# (trips)	# (trips)	7	7	# (trips)
Oldham Lake (Monona)	# (trips)	# (trips)	8	8	# (trips)
Lake Orient (Adair)	# (trips)	# (trips)	5	7	# (trips)

Water Quality Ladder

Name of Lake (County)	Number of Visits		Anticipated Single Day Trips with the higher Proposed Water Quality		
	Actual 2004	Anticipated 2005	Water Quality		Water Quality
			Current	Proposed	
Otter Creek Lake (Tama)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Ottumwa Lagoon (Wapello)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Lake Pahoja (Lyon)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Pierce Creek Lake (Page)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Pleasant Creek Lake (Linn)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Pol Miller Park Lake (Lee)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Prairie Rose Lake (Shelby)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Rathbun Lake (Appanoose)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Red Haw Lake (Lucas)	# ____ (trips)	# ____ (trips)	9	9	# ____ (trips)
Red Rock Lake (Marion)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Roberts Creek Lake (Marion)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Rock Creek Lake (Jasper)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Rodgers Park Lake (Benton)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Saylorville Lake (Polk)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Silver Lake (Delaware)	# ____ (trips)	# ____ (trips)	4	7	# ____ (trips)
Silver Lake (Dickinson)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Silver Lake (Palo Alto)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Silver Lake (Worth)	# ____ (trips)	# ____ (trips)	4	7	# ____ (trips)
Slip Bluff Lake (Decatur)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Lake Smith (Kossuth)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
South Prairie Lake (Black Hawk)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Spring Lake (Greene)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Springbrook Lake (Guthrie)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Storm Lake including Little Storm Lake (Buena Vista)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Lake Sugema (Van Buren)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Swan Lake (Carroll)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Thayer Lake (Union)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Three Mile Lake (Union)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Trumbull Lake (Clay)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Tuttle Lake (Emmet)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Twelve Mile Creek Lake (Union)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Union Grove Lake (Tama)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Upper Gar Lake (Dickinson)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Upper Pine Lake (Hardin)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Viking Lake (Montgomery)	# ____ (trips)	# ____ (trips)	7	7	# ____ (trips)
Volga Lake (Fayette)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Lake Wapello (Davis)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
West Okoboji Lake (Dickinson)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
West Osceola Lake (Clarke)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
White Oak Lake (Mahaska)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Williamson Pond (Lucas)	# ____ (trips)	# ____ (trips)	6	7	# ____ (trips)
Willow Lake (Harrison)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)

Water Quality Ladder

Best possible water quality

10 — Safe to drink

9 —

8 — Safe for swimming

7 —

6 —

5 — Game fish like bass can live in it

4 —

3 — Okay for boating

2 —

1 — Dangerously polluted

0 — Worst possible water quality

Water Quality Ladder

Name of Lake (County)	Number of Visits		Water Quality		Anticipated Single Day Trips with the higher Proposed Water Quality
	Actual 2004	Anticipated 2005	Current	Proposed	
	# ____ (trips)	# ____ (trips)			# ____ (trips)
Wilson Park Lake (Taylor)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Windmill Lake (Taylor)	# ____ (trips)	# ____ (trips)	5	7	# ____ (trips)
Yellow Smoke Park Lake (Crawford)	# ____ (trips)	# ____ (trips)	8	8	# ____ (trips)
Other Lakes in Iowa	# ____ (trips)	# ____ (trips)	No Change		# ____ (trips)

Water Quality Ladder

4. Of the trips you've reported on the preceding pages what percentage of these were
- a) alone or only with members of your immediate household _____ %
- b) with friends or members of another household _____ %
- c) trips members of your household took but you did not + _____ %
- 100 %

Information on you and other members of your household will help us better understand how household characteristics affect an individual's use of Iowa lakes and attitudes towards changes in them. It will also help us to determine how representative our sample is of the state of Iowa. All of your answers are strictly confidential. The information will only be used to report comparisons among groups of people. We will never identify individuals or households with their responses. Please be as complete in your answers as possible. Thank you.

5. What is your age?
- ☐ Under 18 ☐ 26-34 ☐ 50-59 ☐ 76+
- ☐ 18-25 ☐ 35-49 ☐ 60-75
6. You are
- ☐ Male ☐ Female
7. What is the highest level of schooling that you have completed? (Please check only one)
- ☐ Some high school or less ☐ Some college or trade/vocational school ☐ Advanced degree
- ☐ High school graduate ☐ College graduate

8. How many children live in your household (18 or under)? _____
9. How many adults (including yourself) live in your household? _____
10. What is your total household income before taxes for 2004?
☐ Under \$10,000	☐ \$25,000-\$29,999	☐ \$50,000-\$59,000	☐ \$125,000-\$149,000
☐ \$10,000-\$14,900	☐ \$30,000-\$34,999	☐ \$60,000-\$74,999	☐ over \$150,000
☐ \$15,000-\$19,900	☐ \$35,000-\$39,999	☐ \$75,000-\$99,999	☐ \$20,000-\$24,999
☐ \$40,000-\$49,999	☐ \$100,000-\$124,000		
11. How many of the adults you reported in question 9 contribute to your reported household income? _____

Information on employment helps us better understand how time spent working affects an individual's or household's use of Iowa lakes since time spent at a recreational spot is time that cannot be spent at work. Again, all of your answers are strictly confidential. The information will only be used to report comparisons among groups of people. We will never identify individuals or households with their responses. Please be as complete in your answers as possible. Thank you.

12. What is your current employment status?
- ☐ Full time ☐ part time ☐ self-employed ☐ student ☐ unemployed ☐ retired
13. If you are currently employed, how many weeks per year do you work? _____
- 13a. Of these weeks, how many are paid vacation? _____
14. If you are currently employed, how many hours per week do you typically work? _____
15. If you are currently employed, are the number of hours you work per week scheduled for you (for example, your employer requires a 40 hour work week, or schedules hours in advance), or are you free to choose when and how long you work?
- ☐ Fixed/scheduled hours ☐ Free to choose

16. If you had the opportunity to work fewer hours and receive less income, or work more hours and receive more income, would you change your weekly work hours, and if so by how much?

☐ **No, I would not change my weekly work hours**

☐ **Yes, I would change to working fewer hours and receive less income**

- 16a. How many less hours would you work per week, if you could work as many hours as you wanted? _____

☐ **Yes, I would change to working more hours and receive more income**

- 16b. How many more hours would you work per week, if you could work as many hours as you wanted? _____

17. If you are currently employed, are you paid an hourly wage, or do you receive a salary?

☐ **I am paid an hourly wage**

Wage per hour is approximately:

☐ Under \$5.00	☐ \$11.00-\$12.99	☐ \$19.00-\$20.99	☐ \$27.00-\$28.99
☐ \$5.00-\$6.99	☐ \$13.00-\$14.99	☐ \$21.00-\$22.99	☐ over \$29.00
☐ \$7.00-\$8.99	☐ \$15.00-\$16.99	☐ \$23.00-\$24.99	
☐ \$9.00-\$10.99	☐ \$17.00-\$18.99	☐ \$25.00-\$26.99	

☐ **I am paid a salary**

Yearly salary is approximately:

☐ Under \$10,000	☐ \$25,000-\$29,999	☐ \$50,000-\$59,000	☐ \$125,000-\$149,000
☐ \$10,000-\$14,900	☐ \$30,000-\$34,999	☐ \$60,000-\$74,999	☐ over \$150,000
☐ \$15,000-\$19,900	☐ \$35,000-\$39,999	☐ \$75,000-\$99,999	
☐ \$20,000-\$24,999	☐ \$40,000-\$49,999	☐ \$100,000-\$124,000	

If there is a second adult in your household, please answer the same set of questions for that person.

18. What is the other adult's current employment status?

- ☐ Full time ☐ part time ☐ self-employed ☐ student
☐ unemployed ☐ retired

19. If the other adult is currently employed, how many weeks per year does he/she work? _____

- 19a. Of these weeks, how many are paid vacation? _____

20. If the other adult is currently employed, how many hours per week does he/she typically work? ____
21. If the other adult is currently employed, are the number of hours he or she works per week scheduled for him or her (for example, his or her employer requires a 40 hour work week, or schedules hours in advance), or is he or she free to choose when and how long he or she works?
- ☐ Fixed/scheduled hours ☐ Free to choose
22. If the other adult had the opportunity to work fewer hours and receive less income, or work more hours and receive more income, would he/she change his/her weekly work hours, and if so by how much?
- ☐ **No, the other adult would not change his/her weekly work hours**
- ☐ **Yes, the other adult would change to working fewer hours and receive less income**
- 21a. How many less hours would the other adult work per week, if he/she could work as many hours as he/she wanted? _____
- ☐ **Yes, the other adult would change to working more hours and receive more income**
- 21b. How many more hours would he/she work per week, if he/she could work as many hours as he/she wanted? _____
23. If the other adult is currently employed, is he/she paid an hourly wage, or does he/she receive a salary?
- ☐ **The other adult is paid an hourly wage**
- Wage per hour is approximately:
☐ Under \$5.00	☐ \$11.00-\$12.99	☐ \$19.00-\$20.99	☐ \$27.00-\$28.99
☐ \$5.00-\$6.99	☐ \$13.00-\$14.99	☐ \$21.00-\$22.99	☐ over \$29.00
☐ \$7.00-\$8.99	☐ \$15.00-\$16.99	☐ \$23.00-\$24.99	
☐ \$9.00-\$10.99	☐ \$17.00-\$18.99	☐ \$25.00-\$26.99	
- ☐ **The other adult is paid a salary**
- Yearly salary is approximately:
☐ Under \$10,000	☐ \$25,000-\$29,999	☐ \$50,000-\$59,000	☐ \$125,000-\$149,000
☐ \$10,000-\$14,900	☐ \$30,000-\$34,999	☐ \$60,000-\$74,999	☐ over \$150,000
☐ \$15,000-\$19,900	☐ \$35,000-\$39,999	☐ \$75,000-\$99,999	
☐ \$20,000-\$24,999	☐ \$40,000-\$49,999	☐ \$100,000-\$124,000	