WESTERN REGIONAL RESEARCH PUBLICATION

W-133
BENEFITS AND COSTS OF RESOURCES POLICIES AFFECTING
PUBLIC AND PRIVATE LAND

12TH INTERIM REPORT
JUNE 1999

Compiled by
W. Douglass Shaw

Department of Applied Economics and Statistics
Mail Stop 204
University of Nevada
Reno, Nevada 89557-0105

INTRODUCTION

This volume contains the proceedings of the 1999 W-133 Western Regional Project Technical Meeting on "Benefits and Costs of Resource Policies Affecting Public and Private Land." Some papers from W-133 members and friends who could not attend the meeting are also included. The meeting took place February 24th - 26th at the Starr Pass Lodge in Tucson, Arizona. Approximately 50 participants attended the 1999 meeting, are listed on the following page, and came from as far away as Oslo, Norway.

The W-133 regional research project was rechartered in October, 1997. The current project objectives encourage members to address problems associated with: 1.) Benefits and Costs of Agro-environmental Policies; 2.) Benefits Transfer for Groundwater Quality Programs; 3.) Valuing Ecosystem Managment of Forests and Watersheds; and 4.) Valuing Changes in Recreational Access.

Experiment station members at most national land-grant academic institutions constitute the official W-133 project participants. North Dakota State, North Carolina State, and the University of Kentucky proposed joining the group at this year's meeting. W-133's list of academic and other "Friends" has grown, and the Universities of New Mexico and Colorado were particularly well represented at the 1999 W-133 Technical Meeting. The meeting also benefitted from the expertise and participation of scientists from many state and federal agencies including California Fish and Game, the U.S. Department of Agriculture's Economic Research and Forest Services, the U.S. Department of Interior's Fish and Wildlife Service, and the Bureau of Reclamation. In addition, a number of representatives from the nation's top environmental and resource consulting firms attended, some presenting papers at this year's meeting.

This volume is organized around the goals and objectives of the project, but organizing the papers is difficult because of overlapping themes. The last section includes papers that are very important to the methodological work done by W-133 participants, but do not exactly fit one of the objectives. -- I apologize for the lack of consistent pagination in this volume.

On A Personal Note... Any meeting or conference is successful (and fun!) only because of its participants, so I would first like to thank all the people who came and participated in 1999 - listed below. I also want to thank Jerry Fletcher for all his help at this meeting and prior to it, and John Loomis who passed on his knowledge of how to get a meeting like this to work, and who continues to have the funniest little comments to lighten the meetings up. I especially thank Paul Jakus, who helped me to organize this conference and have a lot of fun during it and afterward. Finally, I want to thank Nicki Wieseke for all her help in preparing this volume, and Billye French for administrative support on conference matters.

W. Douglass Shaw, Dept. of Applied Economics & Statistics, University of Nevada, Reno.
June, 1999

P.S. P.F. and J.C. - As far as I can tell, that darn scorpion is still dead!

WELFARE IMPLICATIONS OF SITE AGGREGATION: A COMPARISON OF CONDITIONAL LOGIT AND RANDOM PARAMETERS LOGIT ESTIMATES

Jennifer Murdock

Triangle Economic Research
1000 Park Forty Plaza, Suite 200
Durham, NC 27713
(919) 544-2244

April 30, 1999

WELFARE IMPLICATIONS OF SITE AGGREGATION:

A COMPARISON OF CONDITIONAL LOGIT AND RANDOM PARAMETERS LOGIT ESTIMATES

ABSTRACT

This paper investigates the relationship between site aggregation and calculated welfare effects, comparing a random parameters logit (RPL) specification with a conditional logit (CL) specification. An empirical application to a Montana angling data set where the site definition varies from less aggregate river sites to more aggregate river sites is presented. In this application, the RPL models produce substantially different welfare estimates across the two alternative site definitions, while the results from the CL model are similar. These results indicate important links among IIA violations, site definition, and model specification, where less aggregate sites may cause larger deviation from the IIA property and hence necessitate a more flexible model specification such as the RPL.

1. INTRODUCTION

The effects of model specification on the estimated value of sites or site attributes has received considerable attention in the recreation-demand literature. This interest is in part because of legislation that holds polluters liable for environmental damages making the magnitude of the estimated damage subject to intense peer and court scrutiny.[1] Defining the alternatives that comprise an individual's choice set is fundamental to estimating any random utility model (RUM).[2] This paper focuses on defining alternatives and analyzes the welfare impacts of site aggregation, by comparing two alternative definitions of river sites.[3]

The link between site definition and the Independence of Irrelevant Alternatives Property (IIA) is considered by estimating both a CL and RPL model, which handle error correlation differently. The RPL model does not require the IIA property, which the simple CL does.[4] The sensitivity of the RPL model to alternative site-definition strategies is of further interest given the considerable computer resources required to estimate the more flexible RPL.[5] A smaller choice set also can substantially reduce model estimation resources, but unlike the simple CL model, an RPL model cannot be consistently estimated using known random-draw techniques.[6]

Ben-Akiva and Lerman (1985) label alternatives as either "aggregate" or "elemental". They define elemental sites to be a set of mutually exclusive and collectively exhaustive sites considered by individuals. In other words, a spatial area

---

[1] Under Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Oil Pollution Act of 1990 (OPA) trustees may seek damages for the cost of restoring, replacing, or obtaining the equivalent of an injured natural resource.

[2] See Feather (1994) and Parsons and Hauber (1998) for discussion of the larger question of deciding which alternatives belong in an individual's choice set.

[3] The term "sites" and "alternatives" are used interchangeably in this paper.

[4] A "simple" CL in this paper refers to a one-level conditional logit model that includes no interaction terms to allow for heterogeneous preferences.

[5] The RPL model reported later, with the finer definition of sites and hence larger choice set, took five days to converge on a 450 megahertz PC with 518 meg of available memory.

[6] McFadden (1978) exploits the IIA property of CL to prove that estimating a RUM using random draws of the alternatives provides consistent estimates. Since the RPL does not exhibit the IIA property, the current random-draw techniques are not readily transferable to the RPL.

can be partitioned into elemental sites. Aggregate sites are formed by grouping together elemental sites. Parsons and Needelman (1992) and Feather (1994) define lakes to be elemental sites in their recreational fishing models. This "elemental" site-definition approach is intuitively appealing but not readily transferable to situations where large water bodies or rivers need to be modeled. To model river, Great Lake, bay, or ocean fishing requires defining alternative sites, which is less straightforward than defining an inland lake as a site.[7]

Studies showing the effect of aggregation bias (Parsons and Needelman, 1992 and Feather, 1994), can potentially lead to the conclusion the "smaller is better". While this conclusion is clearly justified in more extreme cases of aggregation, where aggregation includes every lake within a county or a large district, it is less clear what impact lesser levels of aggregation will have. It also is harder to determine whether a site is an aggregate or elemental site when moving towards smaller site definitions. A river, for example, could potentially be divided into extremely small segments. Every 50 miles of a river could be labeled a site, every 10 miles, every mile, every quarter mile, or at the extreme every segment wide enough for an angler to stand. The same argument could be made for the Great Lakes or other large continuous water bodies. Sites that are "too small" will no longer be elemental sites, according to Ben-Akiva's and Lerman's definition, which requires that each trip be associated with only one elemental site. This will not hold if anglers can fish easily at several sites defined for a continuous water body either by walking or boating.

As pointed out by Ben-Akiva and Lerman (1985) the problem of site definition is not unique to recreation demand analysis.

> In other applications, such as the choice of car type, the alternatives are usually grouped by major characteristics of make, model, and vintage, and no distinction is made, for example, among cars of the same make, model, and vintage with different engines.

---

[7] Inland lakes also may not be elemental sites. For example, the popular Lake Winnebago in Wisconsin is an inland lake of over 137,000 acres that spans three counties. Parsons and Needelman (1992) divide this lake into four sites. Chains of lakes, where lakes are inter-connected and in close proximity, also challenge this simple definition of elemental sites.

Site definitions affect the extent to which the model violates the IIA property. The IIA property for a simple conditional logit model holds that the relative choice probabilities of any two alternatives are unaffected by the addition or subtraction of another alternative.[8] This property implies that the error term associated with the utility of each alternative must be independent of the error associated with any other alternative. Manski (1973) identifies four sources of error in the portion of utility unobserved by the researcher: unobserved attributes, unobserved taste variations, measurement errors, and instrumental variables. Whenever these unobserved disturbances *systematically* affect alternatives and induce correlation among their error terms, the IIA property will not hold and the model estimates will be affected. Two common ways to reduce violations of IIA are to include interaction terms that control for heterogeneous preferences or to estimate a nested logit model.

The impact of IIA on welfare estimates is an empirical question because IIA violations can cause welfare estimates to be biased upwards, downwards, or not very biased at all. Researchers have shown that parameter and welfare estimates are sensitive to researcher decisions about alternative model specifications that relax the IIA property. Kling and Thomson (1996) find that specifying a nested model produces results significantly different from a conditional logit model. However, Train (1998) finds that the welfare estimates from a random parameters logit model are not significantly different from that of a conditional logit model. While these results are specific to the data used, the conclusion is that the handling of IIA can influence welfare measures.

The link between the IIA property and site definition arises from the well-know "red bus/blue bus" paradox. This paradox illustrates the inability of the simple logit model to handle a choice problem containing alternatives that are identical or nearly identical (Ben-Akiva and Lerman (1985)). Similar alternatives are likely to have similar unobserved attributes, unobserved taste variations, measurement errors in the attributes, and involve similar instrumental variables. This can produce strong correlation among the error terms associated with these alternatives and result in a strong violation of the IIA property.

---

[8] See Ben-Akiva and Lerman (1985) for a complete discussion.

In this application, the effects of dividing a river segment into multiple sites are explored. In this case, one would imagine that the smaller segments are likely to have error terms correlated with each other because they share the same unobserved characteristics and/or are grouped together by individuals, which links them if these preferences are not observed. The working hypothesis is that smaller sites will result in more serious violations of the IIA property.

Section 2 considers RPL and CL model specifications, Section 3 discusses the data, Section 4 the model results, Section 5 the welfare implications, and Section 6 the conclusions.

2. MODEL SPECIFICATION

The RPL and the CL models differ in their treatment of site-attribute parameters. The simple CL model assumes that individuals choose the site that provides maximum utility and assumes a linear-in-parameters utility function

$$U_{nst} = \beta' X_{ns} + \varepsilon_{ns} \tag{2.1}$$

where ε_{ns} has an i.i.d. extreme-value distribution and sites are indexed $\{1,\ldots,s,\ldots,S\}$, individuals $\{1,\ldots,n,\ldots,N\}$, and trips $\{1,\ldots,t,\ldots,T\}$.[9] The utility function underlying the RPL model looks quite similar to equation 2.1, except that the RPL specification allows β to vary by individual. Hence, the utility function underlying the RPL specification can be written

$$U_{nst} = \beta_n' X_{ns} + \varepsilon_{ns} \tag{2.2}$$

Further, the RPL specifies a distribution for β_n, which in general notation can be written $f(\beta|\theta^*)$. The parameters θ^* characterize the nature of the distribution.

---

[9] For ease of exposition it is assumed that the site characteristics (X) do not vary by trip, only by individual and site. In the application presented, trip cost is the only site characteristic that varies by individual, the remainder vary by site only.

One could rewrite (2.2) to separate the random component of the parameter distribution

$$U_{nst} = b' X_{ns} + \eta_n' X_{ns} + \varepsilon_{ns} \qquad (2.3)$$

where b represents the non-stochastic mean of the distribution and η_n the random deviation from that mean. In equation (2.3), the error term, which corresponds to the two rightmost terms in the equation, contains X_{ns}. The interaction of the site attributes (X_{ns}) with the random error η_n allows correlation in the error terms among alternatives. This in turn ensures that the model does not require the IIA property associated with the simple CL. Further, because β is indexed by n and not by t, it induces correlation across trips taken by the same individual. Thus, the RPL model treats the data as a panel data set. The assumptions of homogeneous preferences and independent trip decisions by the same individual inherent in a simple logit model can be relaxed with an RPL model.[10]

The RPL model estimated in this paper assumes that all of the parameters are random and have independent normal distributions.[11] In other words, the RPL allows for heterogeneous preferences over each of the site attributes. This provides a flexible substitution pattern across sites and does not impose the IIA property.[12]

The simple CL and the RPL represent two extreme approaches to handling the IIA property. The simple CL model exhibits the most restrictive IIA property whereas

---

[10] For more discussion of the underpinnings of the RPL model in a recreation demand context, including simulation techniques and specification issues, see Train (1998).

[11] Other distributions with either bounded or unbounded support could have been selected. Further, the RPL model does not require that all parameters share the same distribution. The normal distribution was selected for all parameters for simplicity, because it allows for both positive and negative reactions to attributes, and because it is a well-known and commonly used distribution to explain economic phenomena. Revelt and Train (1997) discuss in more detail some guidelines for model specification and distribution selection, illustrate the use of both the normal and log-normal distribution, and discuss the possibility of using a distribution with bounded support. Further, Train at the 1999 W-133 meetings suggested that perhaps a bounded support is a better choice because it gives the researcher the ability to prevent individuals from having counter-intuitive preferences.

[12] McFadden and Train (1998) show that under mild regularity conditions, any discrete-choice random utility model with any pattern of substitution and correlation among the error terms can be reproduced by a RPL model with an arbitrarily close degree of accuracy. This implies that the RPL can be made to mimic a nested logit or any other specification designed to handle IIA.

the RPL model allows for a very flexible pattern of substitution. This allows for a test of the sensitivity of models to site definition and its subsequent IIA implications. If a difference were found, future work could examine how more "intermediate" models, such as a nested model, perform in the same experiment.

3. DATA

The data include information on Montana fishing trips taken by Montana anglers during the period from July 1992 through August 1993. Respondents were selected through a random-digit-dial telephone solicitation and asked to return bi-monthly diaries detailing all of their fishing trips.[13] This analysis employs a subset of the data that includes only trips to rivers and single-day trips.

River sites are selected for three reasons. First, substantially better data on site attributes is available for the river sites compared to lake sites. Second, by selecting river sites we have isolated the problem of defining sites over continuous water bodies. Third, by limiting the model to a particular type of site some of the more obvious IIA issues are circumvented. Nested models have been estimated where water body type, fishing mode, or geographic area defines the nest.[14] By selecting only river sites, which attract shore anglers almost exclusively, some sources of potential IIA violations are avoided. The remaining likely cause of IIA violations is spatial. In other words, sites within a certain geographic area are likely to have correlated error terms. This allows a sharper focus on the research question of interest, which is the effect of the size of the defined site, an inherently spatial issue. Single-day trips are included to avoid complicating issues associated with multiple-day / multiple-purpose trips.

Under the less aggregate site specification, 182 unique fishing sites are identified. These sites are defined as the smallest stream segments identified in the Montana Rivers Information System (MRIS), which provides the important site-attribute data. The model contains 750 river trips taken by 199 anglers. With the more

---

[13] For more detailed information on the data please see Desvousges and Waters (1995).

[14] See Kling and Thomson (1996), Desvousges and Water (1995), Morey et al (1993), Morey et al (1991), Bockstael et al (1989) for examples of alternative nesting structures.

aggregate site specification, 53 unique sites are identified. These aggregate sites are defined by combining stream segments based on natural geography and the natural clustering of trips observed in the angler survey. The model contains 810 river trips taken by 210 anglers.[15] The average length of a less aggregate site is approximately 17 miles, whereas the average length of an aggregate site is approximately 57 miles.

Table 1 shows the variables included in the aggregate and less aggregate models and their source.

Table 1.
Variable Definitions

Variable	Less Aggregate Model	Aggregate Model
BIOMASM	Biomass measured as 100 pounds per 1,000 feet of river	Average biomass for river segments within aggregate site
AESMDUM1	Dummy variable for river segments given the highest aesthetics rating	Dummy variable for any river segments given the highest aesthetics rating within the aggregate site
LOGLNGTH	Natural log of the length of the river within the site	Log of the size of the site measured in USGS blocks (LOGSIZE) *
SRAMILE	The number of state recreation areas per mile of river	Number of State Recreation Areas per USGS block within the site (SRABLK)
MAJOR	Dummy variable for sites identified as major in the Angler's Guide to Montana	Dummy Variable for any segment within aggregate site identified as major in the Angler's Guide to Montana
RES_SPEC	Number of restricted species	Number of restricted species
CGMAPBLK	N/A	Number of campgrounds per USBS block in the site
TRIPCOST	Gasoline costs, maintenance costs, plus the opportunity cost of time (1/3 wage rate) to the town nearest the center of the site	Gasoline costs, maintenance costs, plus the opportunity cost of time (1/3 wage rate) to the town nearest the center of the site

* When different from the less aggregate model, the variable name in the aggregate data set is given in parentheses.

---

[15] The difference in the number of trips is believed to result from the added difficulty of assigning individual trips to smaller sites. Some respondents may not have provided enough information to be assigned to the less aggregate sites, but did provide enough information to be assigned to the aggregate sites.

4. MODEL RESULTS

Both RPL and CL models are estimated for the less aggregate and more aggregate sites. The RPL model assumes that all of the parameters are random and have independent normal distributions. The simulated log-likelihood is estimated using 500 draws from the parameter distribution associated with each variable.[16] This number of draws seems sufficient to ensure negligible estimation bias from too few draws.

Table 2 shows the estimation results from these alternative specifications. The log-liklihoods clearly support the RPL specification over the CL specification under both site-definition strategies. This suggests that there is important heterogeneity among preferences captured in the RPL model. With both site definitions, the CL model failed the Small and Hsiao (1982) test for IIA with greater than 99 percent confidence.[17]

The estimated signs of coefficients are stable across the RPL and CL models. Further, the biomass and aesthetic variables have the expected positive sign and the restricted species and trip cost variable have the expected negative signs in all models.[18] Comparing the mean RPL parameters with the CL parameters does not reveal any systematic differences in the estimates, however the significance of the parameter estimates are uniformly higher in the CL specification compared to the corresponding mean estimates in the RPL specification except in two cases.[19] Thus while these models differ substantially in their treatment of IIA the effects on the parameter estimates appear modest.

Turning now to the RPL models only, the standard deviation parameters are nearly all significant, the exception being the standard deviation associated with

---

[16] Revelt and Train (1997) also use 500 draws and Train (1998) uses 1,000 draws.

[17] For a discussion of the test see Ben-Akiva and Lerman (1985). The test was applied using a subset of the sites that are considered major by the Angler's Guide to Montana. For the aggregate site model the test statistic was 75.6 and for the less aggregate model, 60.0.

[18] Given potential differences in tastes for seclusion and size of alternative, there was no expected sign for the major fishing site and log of size variables.

[19] The logsize variable in the less aggregate model is more significant in the RPL specification and the major variable in the aggregate model is more significant in the RPL specification.

biomass in both RPL models and the standard deviation of the log of size term in the aggregate model. The strong significance of the standard deviation terms in general, supports the hypothesis that preferences are in fact heterogeneous among anglers. Another interpretation is that these site attributes are measured with error. The RPL model cannot distinguish between heterogeneous preferences and measurement error, which are observationally equivalent. The hypothesis of measurement error may be supported by the very large standard deviation associated with the aesthetics variable and the insignificance of its mean estimate in both the aggregate and less aggregate models. Assuming a mean of zero, which cannot be statistically rejected, these parameter estimates imply that 50 percent of individuals find aesthetics to be an undesirable attribute. This seems contrary to intuition and suggests possible measurement problems with the aesthetics variable.[20]

The insignificance of the standard deviation of biomass implies that there is not much heterogeneity of preferences among anglers for fish catch. This is a surprising result given that biomass is intended to serve as a rough proxy for expected catch because true expected catch is unobservable. The insignificant sign on the estimated standard deviation implies that biomass may serve as a good proxy for expected catch. In contrast, the standard deviation of trip cost is significant in both the aggregate and less aggregate models. In this case, it is difficult to determine whether this result is driven by measurement error or differences in individual's tastes for travel. Given the simple assumptions built into the travel cost variable about the opportunity cost of time, speed traveled, and standard cost per mile one would expect considerable measurement error. However, the fact that more than 90 percent of individuals consider travel cost to be a negative attribute is encouraging.

[20] Of course the counter-argument that "beauty is in the eye of the beholder" cannot be rejected. However, these parameter estimates imply so much disagreement among individuals as to make this counter-argument unlikely to reflect the entire story.

Table 2.
Estimation Results for CL and RPL with Alternative Site Definitions (Asymptotic t-ratios in parentheses)

	Less Aggregate model (182 sites)		Aggregate model (53 sites)	
	RPL	CL	RPL	CL
BIOMASM	0.014 (1.9)	0.192 (8.0)	0.304 (2.8)	0.266 (4.0)
SD(BIOMASM)	0.158 (1.5)	-	0.256 (1.6)	-
AESMDUM1	0.448 (1.6)	0.656 (6.4)	0.320 (1.9)	0.661 (6.0)
SD(AESMDUM1)	2.336 (5.4)	-	0.845 (3.7)	-
LOGSIZE	0.439 (3.4)	0.160 (2.3)	0.759 (4.3)	0.528 (5.1)
SD(LOGSIZE)	1.037 (8.4)	-	0.197 (0.4)	-
MAJOR	0.564 (2.2)	0.575 (5.3)	1.045 (3.6)	0.329 (1.9)
SD(MAJOR)	1.906 (5.9)	-	0.920 (2.2)	-
RES_SPEC	-0.285 (-1.7)	-0.346 (-5.1)	-0.831 (-4.3)	-0.484 (-6.9)
SD(RES_SPEC)	0.649 (2.9)	-	0.606 (3.7)	-
TRIPCOST	-0.133 (-21.7)	-0.090 (-32.2)	-0.121 (-15.4)	-0.097 (-30.8)
SD(TRIPCOST)	0.058 (11.6)	-	0.042 (5.6)	-
LOG-LIKELIHOOD	-1845	-2272	-1240	-1533
LIKELIHOOD RATIO INDEX	0.527	0.418	0.614	0.523

5. WELFARE RESULTS

This section compares the welfare impact of potential improvements across four alternative models. Two potential improvement programs are considered. The first increases the biomass by 100 pounds per mile at all sites. The average biomass at the aggregate sites is approximately 103 and at the less aggregate sites, approximately 83 pounds. The second program doubles biomass at all sites. The standard deviation of biomass is 110 at the aggregate sites and 155 at the less aggregate sites. These two programs do not differ much for the "average site", but may have very different affects overall because of the wide dispersion of the biomass among sites. In other words, a site with below average biomass will benefit more from the first program whereas a site with above average biomass will benefit more from the second program. The average value of an aggregate site is also compared across models. Valuing an aggregate site allows direct comparisons between the results from models estimated with the aggregate and less aggregate sites. For the less aggregate models, the group of sites contained within the aggregate site is valued. This estimate allows a more general comparison among the models that is not as dependent on the estimated biomass parameter as the two improvement programs.

The calculation of the welfare change for each individual, in terms of the compensating or equivalent variation, follows equation 5.1. In equation 5.1, X1 represents the individual's attribute matrix in the improved state, X0 represents the individual's attribute matrix in the original state, and the summations are over the alternatives in an individual's choice set.

$$CV_n = EV_n = -1/\beta_{TC} * \{ \ln(\sum e^{X1\beta}) - \ln(\sum e^{X0\beta}) \} \quad (5.1)$$

The calculation of welfare within the RPL model requires simulation over β to estimate equation (5.1) since the RPL model does not estimate β but rather a distribution of β. Estimates are obtained by randomly drawing 10,000 parameters from the normal distribution associated with each of the explanatory variables. Because the parameter on travel cost appears in the denominator of the welfare expression, care must be taken to avoid parameter draws near zero. Given the distribution of the travel cost parameter in both RPL models, truncation at plus and minus one standard deviation is chosen.[21] Welfare estimates computed using the mean of the travel cost distribution rather than the truncated distribution did not differ substantially from those reported.[22]

Table 3 shows the estimated welfare implications of the two improvement programs. One way to interpret these results is to compare the two less aggregate site models and then the two aggregate site models. With the less aggregate site definition, the estimated value of the two improvement programs differs substantially between the CL and RPL. The RPL estimates a gain of $0.90 per trip for program 1 whereas the CL estimates a gain of $2.13 per trip. The estimated gains for program 2 also differ by more than a factor of two between the RPL and CL specification, $2.23 and $4.57 per trip respectively. These results indicate that with the less aggregate site definition there are substantial differences between the RPL and CL welfare estimates. The models estimated with the aggregate sites tell a different story. Here, the RPL model predicts a slightly lower benefit from program 1, $2.60 versus $2.75 for the CL, but the RPL model predicts a slightly higher benefit from program 2, $4.47 versus $4.07 for the CL. The results with the aggregate site definition indicate no systematic difference between the RPL and CL models in terms of their welfare predictions.

The result that RPL and CL models perform similarly, at least in terms of predicted welfare changes, with aggregate sites but quite differently with less aggregate sites supports the original hypothesis that IIA violations may be more serious when sites are defined as smaller areas. Models that differ in their treatment of the IIA issues seem to differ in their reaction to site definition.

---

[21] This is achieved by drawing 20,000 β_n's, removing those β_n's with travel cost parameters outside of one standard deviation, and then randomly keeping 10,000 of those remaining.

[22] For the less aggregate site RPL model the following welfare estimates are obtained using the mean of travel cost: $0.89 for program 1, $2.12 for program 2, and 0.28 is the average value of a site. For the aggregate site RPL model the following welfare estimates are obtained using the mean of travel cost: $2.60 for program 1, $4.43 for program 2, and 0.24 is the average value of an aggregate site. These results are very similar to those reported in Table 3.

Table 3.
Estimated Welfare Changes per Trip

	PROGRAM #1: Increase Biomass by 100 lbs. per mile at all sites	**PROGRAM #2:** Double Biomass at all sites	**AVERAGE TOTAL USE-VALUE OF AN AGGREGATE SITE**
LESS AGGREGATE MODELS			
RPL	0.90	2.23	0.27
CL	2.13	4.57	0.24
AGGREGATE MODELS			
RPL	2.60	4.47	0.24
CL	2.75	4.07	0.25

Alternatively, one could read the table by comparing the two CL models with each other and the two RPL models with each other. The RPL model appears to be sensitive to the two alternative definitions of site. Under program 1, the RPL model predicts a smaller welfare gain of $0.90 with the less aggregate site definition compared to $2.60 with the aggregate definition. Similarly, under program 2, the RPL model predicts a smaller welfare gain of $2.23 with the less aggregate site definition compared to $4.47 with the aggregate definition. The RPL model detects a difference of more than a factor of two, in terms predicted welfare, between the alternative site definitions. In contrast to RPL, the CL model does not appear to be sensitive to the two alternative definitions of site. Under program 1, the CL model predicts a smaller welfare gain of $2.13 with the less aggregate site definition compared to $2.75 with the aggregate definition. However, under program 2, the CL model predicts a larger welfare gain of $4.57 with the less aggregate site definition compared to $4.07 with the aggregate definition. For the CL, the welfare estimates across site specifications are quite close for both programs and do not appear to differ in a systematic manner. The CL model does not appear to detect a difference, in terms predicted welfare, between the alternative site definitions. This result indicates that violations of IIA may mask welfare differences resulting from alternative site definitions. This could lead to the faulty conclusion that the size of the defined sites is not important to the calculation of welfare gains.

The third column of Table 3 shows the estimated average value of an aggregate site. This value does not seem to vary substantially across models. However, as noted for the policy improvement scenarios, the difference between the RPL and CL with the less aggregate sites is greater than the difference between these two models with the more aggregate sites. Also consistent with the above findings is that there is a greater difference between the RPL models across site definitions than the CL models.

Some caution when interpreting the RPL model results is warranted. The desirable properties of the RPL are accompanied by the challenge of deciding which parameters should be allowed to vary and which distributions should be used. The effects of model specification issues, especially the choice of parameter distributions, has not been fully discussed in the literature. Additional research on specification decisions and their impact on parameter and welfare estimates is needed before strong conclusions can be made.

6. CONCLUSIONS

This paper investigated the relationship between site definition and the calculated welfare effects, comparing a Random Parameters Logit (RPL) specification with the Conditional Logit (CL) specification, with an empirical application to a Montana angling data set. The more aggregate sites correspond to approximately 57 miles of river and the less aggregate sites to approximately 17 miles of river.

In this application, the RPL models produce substantially different welfare estimates when aggregate sites are used compared to the less aggregate sites, whereas the results from the CL model are nearly identical for the two alternative site definitions. Thus, while the RPL model detects a difference between the aggregate and less aggregate site definitions, the CL does not seem to detect a difference. The failure of the CL model to detect a difference between the aggregate and less aggregate site definitions indicates that violations of IIA may mask welfare differences resulting from alternative site definitions. This could lead to the faulty conclusion that the size of the defined sites is not important to the calculation of welfare gains.

The result that RPL and CL models perform similarly, at least in terms of predicted welfare changes, with aggregate sites defined but quite differently with less aggregate sites defined supports the original hypothesis that IIA violations may be more serious when sites are defined as smaller areas. Dividing a larger site into several smaller sites may worsen IIA violations because the error components of these smaller sites are likely to be correlated. Random errors related to heterogeneous preferences, unobserved variables, and proxy variables are likely to effect the smaller sites in similar ways. Thus defining smaller sites may increase the severity of IIA violations. This can explain why a substantial difference between RPL and CL is only noted in the less aggregate site specification where IIA is more likely to be a serious concern and the added flexibility of the RPL more necessary. These results suggest that when smaller sites are identified more attention to IIA is warranted and a more flexible model specification such as the RPL may be necessary.

REFERENCES

Ben-Akiva, M., and S.R. Lerman. "Discrete Choice Analysis: Theory and Application to Travel Demand." Cambridge: MIT Press, 1985.

Bockstael, N., K. McConnell, and L. Strand. 1989. "A Random Utility Model for Sportfishing: Some Preliminary Results for Florida." *Marine Resource Economics* 6: 245-60.

Desvousges, W., and S. Waters. 1995. "Report on Potential Economic Losses Associated with Recreational Services in the Upper Clark Fork River Basin." Vol. III and Appendices, Triangle Economic Research, Durham, NC.

Feather, Peter M. 1994. "Sampling and Aggregation Issues in Random Utility Model Estimation." *American Journal of Agricultural Economics* 76 (Nov.): 772-780.

Kaoru, Yoshiaki, V. Kerry Smith, and Jin Long Lui. 1995. "Using Random Utility Models to Estimate the Recreational Value of Estuarine Resources." *American Journal of Agricultural Economics* 77: 141-151.

Kling, C.L., and C.J. Thomson. 1996. "The Implications of Model Specification for Welfare Estimation in Nested Logit Models." *American Journal of Agricultural Economics* 78 (Feb): 103-14

Manski, C. 1973. *The Analysis of Qualitative Choice*. Ph.D. dissertation. Department of Economics, MIT, Cambridge, Mass.

McFadden, Daniel. 1978. "Modeling the Choice of Residential Location." *Spatial Interaction Theory and Planning Models*, eds. A. Karlqvist et al., 75-96. Amsterdam: North-Holland Publishing.

McFadden, Daniel, and K. Train. 1998. "Mixed Multinomial Logit Models for Discrete Response." Working Paper, Department of Economics, University of California, Berkeley.

Morey, E., R. Rowe, and M. Watson. 1993. "A Repeated Nested-Logit Model of Atlantic Salmon Fishing." *American Journal of Agricultural Economics* 75 (3): 578-92.

Morey, E., W. Shaw, and R. Rowe. 1991. "A Discrete-Choice Model of Recreational Participation, Site Choice, and Activity Valuation When Complete Trip Data Are Not Available." *Journal of Environmental Economics and Management* 20 (2): 181-201.

Parsons, George R., and A. Brett Hauber. 1998. "Spatial Boundaries and Choice Set Definition in a Random Utility Model of Recreation Demand." *Land Economics* 74 (1): 32-48.

Parsons, George R., and M.S. Needelman. 1992. "Site Aggregation in a Random Utility Model of Recreation." *Land Economics* 68 (Feb.): 418-33.

Revelt, D., and K. Train. 1997. "Incentives for Appliance Efficiency: Random Parameters Logit Models of Households' Choices." *Review of Economics and Statistics:* forthcoming.

Small, K., and C. Hsiao. 1982. "Multinomial Logit Specification Tests." Working Paper. Department of Economics, Princeton University, Princeton, N.J.

Train, Kenneth E. 1998. "Recreation Demand Models with Taste Differences Over People." *Land Economics* 74 (2): 230-39.