

# Using Revealed Preference Behavioral Models to Correctly Account for Substitution Effects in Economic Impact Analysis

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**Abstract.** This study presents a methodology to correctly account for substitution patterns in estimates of final demand used in economic impact analysis. Then, this methodology is demonstrated empirically using recreational tourism data. Specifically, this study a) presents the results of a behavioral model for recreation demand; b) uses the predictions from this model to drive changes in final demand for an input-output economic impact model; and c) presents results from this impact model, contrasting them with the naïve assumption of no/limited substitution. Empirical results indicate that failure to account for substitution in final demand could result in gross overestimates of economic impacts.

## 1. Introduction and problem statement

Regional economic impact analysis is used to measure the amount of economic activity created by a particular business, industry, or sector of an economy. Impact analyses are often employed to influence policy, as well-intentioned policymakers, with the interests of their constituents in mind, try to craft policies with the broadest and greatest benefits possible. Unfortunately, the economic “impact” analyses utilized are, in many cases, merely measurements of economic activity (Watson et al., 2009). Instead, a true impact analysis should measure the *change* in regional economic activity brought forth by changes in an industry or sector of the economy.

Examples abound, including the economic impact of recreational amenities such as state parks (Bergstrom et al., 1990), river recreation (Cordell et al., 1990), charter and party boat fishing (Steinback, 1999), and sportfishing (ASA, 2008). Other studies demonstrate the economic impact of public infrastructure such as parking garages (Martin Associates, 2009), events centers (Markin Consulting, 2006), and stadiums (e.g., Coates and Humphreys, 2000).

Again, however, nearly all of these studies simply provide a snapshot of the economic contribution of these facilities, offering little information in terms of effects of potential *changes* in scope, quantity or quality on final economic activity. This failure to account for true changes in final demand (resulting from a proposed amenity change) will certainly bias economic impact estimates upward: without said amenity, consumers will merely shift their consumption to the next-best-thing, which may also be within the region of analysis.

In order to assess the change in regional economic activity generated from amenity quality or quantity changes, an intuitive approach would be to model an economy with and without the proposed change and then measure the difference in economic activity (e.g., effects of imported tourism dollars) associated with that change. However, while the status quo can be used to model the “without” scenario, researchers must rely on some form of either stated or revealed preference data to forecast what the “with” scenario would be like.

To date, only a small handful of studies have adopted this approach. Bergstrom et al. (1996) use a

contingent behavior questionnaire to predict changes in trips associated with various aquatic plant mitigation plans, which is subsequently used to estimate changes in economic impacts. Hamel et al. (2002) and Criddle et al. (2003) adopt a similar approach to estimate the economic impact of an Alaskan sport fishery, and Loomis (2006) uses information from a stated-preference contingent behavior survey of anglers to estimate the economic impacts of changes in catch rates of trout in the Snake River in Idaho and Wyoming. Finally, Weiler et al. (2003) and Weiler and Seidl (2004) use revealed visitation patterns over time to predict changes in visitation to a National Monument resulting from changing its designation from "National Monument" to "National Park." These changes are then linked with input-output models of regional economic activity to forecast the economic impact of changing the park's designation.

Although the aforementioned studies account for hypothetical changes in tourism resulting from changes in amenity quality, there are several shortcomings which should be addressed. First, while stated preference methodology is utilized throughout the economic literature, hypothetical bias (see Murphy et al. [2005] for a review of this literature) and a lack of understanding of the hypothetically proposed good (see Arrow et al., 1993) can result in estimates that are very different from their true value. Second, the revealed-preference methodology utilized in Weiler et al. (2003) and Weiler and Seidl (2004) is plagued by the fact that it requires many years of data. Third, and most importantly, none of these studies explicitly address visitor substitution possibilities within the region of analysis: if consumers substitute from their current choice within the impact area to an improved choice within the impact area, there may be little or no change in the level of regional economic activity.

A repeated nested logit (RNL) model, as developed by Morey (1993) and refined in Morey (1999), offers a solution to the aforementioned issues. First, the RNL is based on revealed preference data, mitigating potential concerns regarding hypothetical bias in stated-preferences. Second, the utility-theory-consistent RNL, an econometric specification of the random utility model (RUM), allows researchers to use current substitution patterns across a multitude of site choices (using cross-sectional data) to estimate the change in visitation probability associated with a change in amenity quality at one (or many) site(s). Third, the RNL directly accounts for the substitution to in- and out-of-region sites which

drives changes in in-region demand and economic activity.

In his dissertation, Bastian (2004) uses the RNL to predict substitution patterns of snowmobilers in response to site closure in Yellowstone National Park and then link these predictions with input-output models of the northwestern Wyoming regional economy. However, the only policy proposal in that study was site closure: no consideration was given to the potential economic impacts of changes in site quality. As most management decisions involve changes in amenity quality, evaluating the economic impacts of such changes will be of general interest to researchers and policymakers alike.

In order to address this gap in the literature, this study presents a methodology for using predictions from a revealed preference behavioral model (specifically the RNL) to drive changes in final demand in an input-output model in order to estimate the economic impacts of not only site closure, but also changes to site quality. Although this paper focuses on recreational site modification, the approach adopted could very easily be applied to estimate the economic impacts of changes in other amenities such as transportation choices for travelers, urban amenities such as events centers or stadiums, or parking choices for visitors to a city.

This study contributes to the recreational impact literature in several ways. First, this will be only the second study (after Bastian's (2004) dissertation) which uses predictions from a revealed preference RUM to drive final demand changes in an input-output model in order to forecast changes in economic activity. As this methodology is both utility-theory-consistent and based on revealed preferences, it should advance the literature regarding tourism and regional economic development. Second, this will be the first study to use a revealed preference RUM to forecast changes in economic activity coming from changes in amenity quality. As many management regimes involve quality changes rather than outright closures, this approach should prove useful to resource managers and economists alike. Third, this paper empirically contrasts the correct economic impact model (while accounting for substitution) to the more naïve model (the traditional model) which does not account for substitution. Empirical results indicate that the differential between correct and incorrect specification could be substantial.

This paper proceeds as follows. The next section provides a theoretical exposition of the models used in this paper. Next, an empirical example is

provided, including information about the data collected and the specific region of analysis. Finally, sections summarizing some illustrative example results of the models are provided, followed by a brief section to conclude and summarize the implications of this study.

## 2. Theoretical and empirical models

### 2.1. Regional economic model

An input-output (IO) model is used to estimate the multipliers commonly used in regional economics. In the case of this study, IMPLAN IO software is used (MIG INC., 1997). IMPLAN uses pre-existing data for industries within a region to generate linear production functions which relate the amount of final demand for a particular sector's products with the amounts of inputs required to achieve that level of final demand. Formally:

$$Y = (I - A) * X, \quad (1)$$

where  $Y$  represents the final demand for goods,  $I$  is an identity matrix,  $X$  is a vector of inputs and  $A$  is a matrix of technical coefficients which link inputs to outputs in all sectors. Solving for  $X$  yields

$$X = (I - A)^{-1} * Y, \quad (2)$$

or the amount of input,  $X$ , needed to satisfy final demands,  $Y$ .  $(I-A)^{-1}$  is the matrix of technical interdependence coefficients which measure direct and indirect levels of inputs needed to achieve final demand  $Y$  (see Miller and Blair, 2009, for an excellent discussion of IO models).

### 2.2. Revealed preference visitation model

Solving for the economic impact of some activity within a region requires accounting for the direct, indirect, and induced effects ( $X$ ) of final expenditures ( $Y$ ) with and without that activity. However, elimination or modification of one alternative or changes in quality attributes of that alternative will not necessarily result in visitors refraining from engaging in economic activity in the region. While some will elect to visit another region, others will simply visit a nearby within-region site and make similar within-region expenditures.

The random utility model (RUM) can be utilized to model substitution patterns across various alternatives. The RUM can be derived as follows, as seen in Haab and McConnell (2002) and Parsons (2003). Individuals derive utility from some activity. While

the individual decision maker has full knowledge of his indirect utility function, the researcher only observes behavior, and as such there is a random or unobserved component. The indirect utility ( $v$ ) associated with making a particular choice  $j$  for an individual  $i$  is

$$v_{ij} = \beta_{ic} * c_{ij} + \beta_{Q_j} * Q_j + \varepsilon_{ij}, \quad j = 1, \dots, J \quad (3)$$

where  $c_{ij}$  represents the cost for individual  $i$  associated with alternative  $j$  (within some choice set) and  $Q_j$  represents a vector of other attributes associated with alternative  $j$ . The indirect utility of an alternate activity is

$$v_{i0} = \alpha_{i0} \cdot \lambda_{i0} + \varepsilon_{i0} \quad (4)$$

where  $\lambda_{i0}$  represents a set of individual attributes, and  $\alpha_{i0}$  represents the vector of coefficients on these variables. Then, an individual maximizes his current-period utility by choosing the alternative which yields the highest utility:

$$u_i = \max(v_{i0}, v_{i1}, v_{i2}, \dots, v_{iJ}) \quad (5)$$

The repeated nested logit (RNL) discussed in the introduction is one econometric specification of the RUM. In the RNL estimated for the present analysis, individuals are assumed to maximize utility by deciding whether to partake in a particular activity and, if so, in which region to partake in that activity (each of these choices is considered a "nest"). Finally, the individual decides at which site to partake in said activity. For this model, the probability of visiting a particular site on a particular choice occasion is  $p_m * p_{j|m}$ , which is the probability of selecting nest  $m$  multiplied by the conditional probability of selecting site  $j$  given the selection of nest  $m$ . Although a variety of econometric specifications could be adopted, for the reasons outlined in the introduction, the specific functional forms of these probability statements are as follows:

$$p_m = \frac{e^{\ln \left[ \sum_{j=1}^J e^{X_j \beta} \right] \cdot \theta_m}}{\sum_{m=1}^M \left\{ e^{\ln \left[ \sum_{j=1}^J e^{X_j \beta} \right] \cdot \theta_m} \right\}} \quad (6)$$

$$\text{and } p_{j|m} = \frac{e^{X_j' \beta}}{\sum_{j=1}^{J_m} e^{X_j' \beta}} \quad (7)$$

as detailed in Hensher et al (2005), where  $m \in M$  (nests) and  $j \in J$  (choices within a nest), and  $J_m$  represents the total number of sites within nest  $m$ . The parameter  $\theta$ , sometimes referred to as an Inclusive Value or IV parameter, essentially indicates the level of dissimilarity of choices between nests.  $X_j' \beta$  (in the econometric model) is equivalent to  $V_{ij}$  (in the theoretical model), or the indirect utility function from equation (3) for site  $j$  within nest  $m$ . This probability statement is actually fairly intuitive: the numerator is the weight placed on each individual site, while the denominator is the weight (inversely) placed on all sites.

The expected number of visitor days in a particular time period is:

$$E(\text{VisitorDays}) = A \cdot C \cdot p_m \cdot p_{j|m} \quad (8)$$

where  $C$  is the total number of available choice occasions,  $A$  is the total number of potential visitors, and  $p_m \cdot p_{j|m}$  gives the probability that a particular visitor visits the site on a particular choice occasion.

### 2.3. Linking the RNL and Input Output models

The RNL is used to predict the level of final demand in a particular region with and without a particular management action. Then, each of the two scenarios' economic contribution of visitor days is simulated in IMPLAN input-output software. The difference between the two scenarios' economic contribution is the marginal effect of the management action on economic activity (i.e., the true economic impact of that management action). Formally:

$$\Delta X = (I - A)^{-1} * \Delta Y \quad (9)$$

as in Bastian (2004), where  $\Delta Y$  represents the change in overall expenditures by visitors within the region (simulated with the RNL), and  $\Delta X$  represents the total change in in-region output resulting from the change in final expenditures. In the next section we illustrate the empirical tractability of linking the RNL and IMPLAN. We do this using data on fishing for stocked fish in California.

### 3. Case study: fish stocking in Mono County, California

Mono County is a destination that contains some of the best fishing in California (Stienstra, 2008). What makes Mono County fisheries unique, aside from the aesthetic beauty of the area, is that the fish contained in its lakes and rivers are large and plentiful. Much of the fishing is supported by heavy stocking programs, both by the California Department of Fish and Game and by private industry (Fish and Game, 2010). Finally, Mono County's population is only 12,927 (US Census, 2009), but there are an estimated 337,807 visiting angler days spent in that region (see next section). As such, potential changes to fish stocking policy may have large economic impacts on the region.

Although Mono County hosts some of the best fishing in California, and Mono County fisheries receive heavy stocking from both the private and public sectors, three of six major fisheries (Convict Lake, Hot Creek, and Mammoth Lakes) are within the historic range of the critically endangered Mountain Yellow-Legged Frog (Parker, 1994). This has led to several lawsuits, in which the plaintiffs accused California Department of Fish and Game (CDFG) of failing to follow the California Environmental Quality Act and ultimately driving this, as well as 30 other species, to endangered status (ICF Jones and Stokes, 2010). CDFG lost the case. In the future, policies stemming from this lawsuit to mitigate the adverse effects of introduced fish on native frogs may include the closure of fisheries and removal of fish, or simply halting of the trout stocking program (see Armstrong and Knapp, 2004; Knapp et al., 2007; and ICF Jones and Stokes, 2010<sup>1</sup>).

In subsequent sections, the models described in section 2 are used to predict angler substitutions, and resulting economic impacts, resulting from such fish stocking policies. Then, these results are compared with results derived from a more standard economic impact analysis which fails to account for substitution possibilities.

During the summer and fall of 2009, anglers at 17 public fisheries in and around Mono County were surveyed in order to obtain a representative sample of anglers at a variety of location types. Surveys were distributed in person on site in most cases. A thank you/reminder postcard was mailed 10 days

<sup>1</sup> The recent California EIS (2010) does not explicitly suggest trout removal as an alternative, but Knapp et al. (2007) demonstrates that trout removal is feasible and can lead to the recovery of frog populations.

after the first contact, and a second survey was mailed a week later for any who had not yet responded. For more information about the survey distribution process, see Deisenroth and Bond (2010).

The angler survey asks how much anglers spent on their most recent trip in a number of expenditure categories within and outside of the western region. Anglers were also asked about the number of trips they had taken to a variety of sites (48 in total) within the past year. In total, 613 surveys were distributed to anglers at California public sites, with 359 surveys returned for a response rate of 58.5%.

Although there are many small streams and rivers in Mono County, six major fisheries were selected for analysis in this study (Bridgeport Reservoir, Convict Lake, Crowley Lake, Hot Creek, June Lake Loop, and Mammoth Lakes). It is assumed, for the purpose of this study, that these bodies of water harbor *all* angler activity in the region. As such, the estimates provided in subsequent sections may not be as precise as they could have been had data been collected about all fishing sites in Mono County. However, the six aforementioned fisheries likely occupy a majority of angler days, rendering this simplifying assumption defensible. The present model assumes 100 recreational choice occasions per year to coincide with the period of highest fishing activity (Memorial Day through Labor Day)<sup>2</sup>.

## 4. Results

### 4.1. Status quo angler tourism and economic contributions

The following example is provided for illustrative purposes, as the precise number of total angler days in Mono County is unknown. However, Mono (2009) provides survey information which can be

<sup>2</sup> The fishing season in Mono County (the region of analysis for this study, see next section) is from April 30<sup>th</sup> – November 15<sup>th</sup>, allowing for a potential angler to fish for 195 days. However, it is extremely unlikely (as corroborated by our data) that any angler would fish for this many days due to employment and other constraints, so it is assumed for this illustrative example that he chooses whether or not to fish on a maximum of 100 days. Further, there are many warm-water fisheries in California with year-round fishing access, in which case the 100 days represents the roughly 100 weekend days. The few anglers who indicated that they fished for more than 100 days at any site during the year (i.e., some respondents indicated that they fished for 365 days because they lived on-site) were eliminated from the sample. This was only 30 out of the 359 total anglers sampled in California. In fact, the number of days in an angler's choice set is largely endogenous, depending on a number of factors, but likely depending primarily on employment status.

used to roughly estimate the number of primary-purpose angler days spent each year by visitors to Mono County. Their survey asked visitors to indicate the average number of individuals in a group and the primary purpose of the trip. That study also indicates the total number of occupied lodging sites<sup>3</sup> on an annual basis. Using this data, annual angler days is estimated formally as follows:

$$A = \varphi \cdot \gamma \cdot \eta \cdot \iota \cdot \kappa \cdot O \quad (10)$$

where  $\varphi$  represents total annual sites occupied,  $\gamma$  represents average persons per group,  $\eta$  represents the percentage of visitors whose primary travel purpose was to visit Mono County,  $\iota$  represents the percentage of visitors whose primary purpose of visiting Mono County was to experience the outdoors, and  $\kappa$  represents the percentage of primarily outdoor travelers who engaged in fishing on their trip.  $O$  is an additional parameter representing the fraction of group members who engaged in fishing, which is assumed to be 50% for this analysis<sup>4</sup>. Finally, although Mono (2009) did not indicate whether fishing was a primary purpose of travel, the assumption here is that all anglers whose primary purpose of travel was to visit Mono County and experience the outdoors were primarily visiting in order to fish. Given the nature of the destination fisheries in Mono County, this is a defensible assumption for the purpose of illustrating our model.

By equation (9), there are an estimated 337,807 visitor angler days per year in Mono County<sup>5</sup>. Table 1 illustrates the average daily spending patterns of anglers surveyed in this study. The largest expenditure category is gasoline, of which half is assumed to be spent in-region<sup>6</sup>. Other major categories include guide fees, restaurant meals and groceries, and hotels. This information is used to shock the appropriate industries in IMPLAN input-output software in order to estimate the regional economic impact of sportfishing in Mono County, California.

<sup>3</sup> A "site" may be a campsite, hotel, motel, or condominium.

<sup>4</sup> This represents the possibility that a family visits Mono County, and only a fraction of that family fishes. This is an assumption that will have only a linear effect on final results.

<sup>5</sup> This uses overnight stays as a proxy for the number of days spent in Mono County by anglers. However, only individual day trips are used to calculate angler substitution patterns in the next section.

<sup>6</sup> Some anglers may not purchase any gasoline in Mono County, whereas others spend more in Mono County than what would be required for the round trip from home to the fishery (i.e., a fill-up). Still, on average, 50% makes sense due to the round-trip nature of anglers' trips.

**Table 1.** California angler daily expenditures.<sup>a</sup>

	Amount Spent/Day	Amount Spent in Mono County on a Day Trip	Accounting for Retail Margins
Gasoline	\$52.79	\$26.39	\$4.33
Restaurant Meals	\$16.21	\$16.21	\$16.21
Groceries	\$16.15	\$16.15	\$4.75
Camping	\$4.02	\$0	\$0
Hotels	\$18.36	\$0	\$0
Guide and License Fees	\$32.98	\$32.98	\$32.98
Fishery Entrance Fees	\$6.69	\$6.69	\$6.69
Car Rentals	\$0.53	\$0	\$0.00
Airlines	\$0.28	\$0	\$0.00
Other	\$31.49	\$31.49	\$12.53
Total	\$179.51	\$129.92	\$77.49

<sup>a</sup>Hotels and campsites are excluded for this part of the analysis in order to align with day-trip estimation results in subsequent sections. However, this does result in an underestimate of the economic impacts of sportfishing to Mono County.

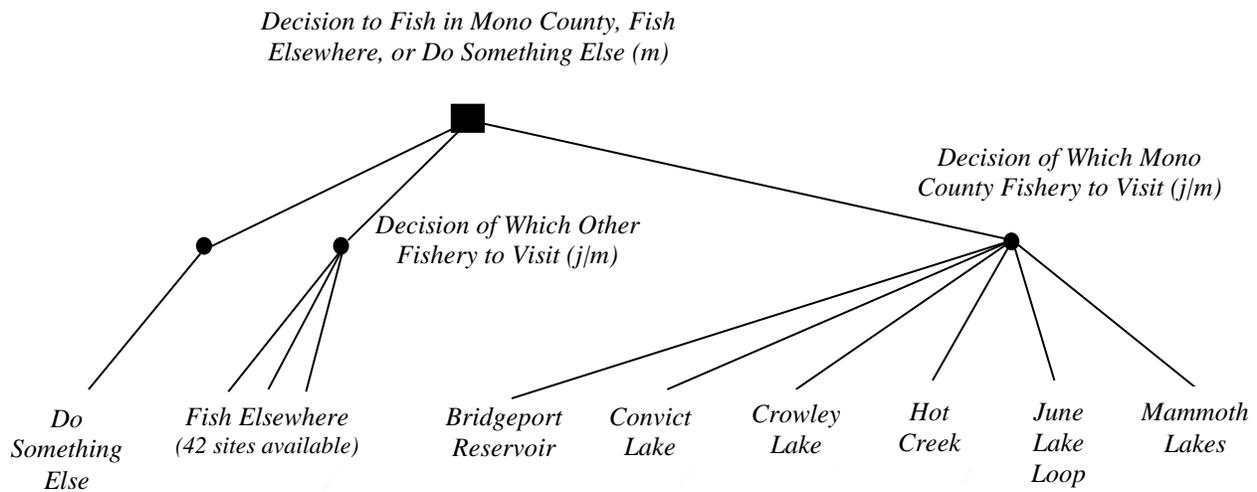
IMPLAN input-output software is used to find that for every dollar spent by anglers in Mono County (accounting only for retail margins, as opposed to gross retail sales), an additional \$0.29 dollars are generated within Mono County (all export dollars). The high amount of leakage, and thus low multiplier, is due to the small region size. Given this multiplier, the economic contribution per angler day is \$99.56, yielding a total economic contribution of sportfishing to Mono County, in terms of output, is \$33.6 million annually (all export dollars).

#### 4.2. Angler substitution patterns

The model presented in section 4.1 assumes that in the absence of sportfishing in Mono County, anglers would simply leave and spend their dollars elsewhere. However, in the event that one fishery (or several fisheries) in Mono County were to be closed, or in the event that catch rates at one fishery (or several fisheries) were to fall, the model presented above cannot predict what sorts of impacts may accrue to the region.

In order to capture the potential substitution patterns that anglers may exhibit when presented with varying fishery characteristics, surveyed anglers were asked about the number of days spent at a variety of sites within the past year<sup>7</sup>. Then, a RNL of angler preferences for fishery attributes (see section 2.2) was estimated. This model captures both angler preferences for various site attributes as well as demographic factors which would change anglers' likelihood of going fishing. In the present RNL, anglers are assumed to choose whether to fish in Mono County, fish elsewhere, or do something else (outside of Mono County). If the decision is to fish, the angler decides which fishery to visit. The decision does not need to be sequential: the "decision tree" appearance of the model (figure 1) is only to allow for differences in variances across nests, but not within nests (Hensher et al., 2005).

<sup>7</sup> Predicted visitation to surveyed sites is weighted using the sample reported trip distribution. Although this may bias the results towards one site or another, since surveys were collected on-site, no other information is available regarding annual visitation at the study sites. However, since anglers report annual trips to all sites, rather than just their most recent trip, the bias may be somewhat mitigated.



**Figure 1.** 2-Level Repeated Nested Logit Model of anglers' decision process.

Table 2 presents the variables used in the RNL, along with their definitions, and table 3 presents summary statistics for the six surveyed Mono County sites. Variables were included to capture differences across fisheries as well as across anglers (i.e., different travel costs for different anglers). These variables capture elements of fishing quality and scenic beauty as well as access costs, and they generally coincide with the literature (e.g., Johnson et al., 2006, Morey et al., 2003).

One variable which deserves a bit of attention, as it is the focus of any policy regarding fish stocking, is catch per unit effort (or fish caught per hour). The survey questionnaire asked questions about an angler's most recent trip as well as questions about their trips within the last year. However, catch rate information was only collected from the recent trip. In order to simulate anglers' expected catch rates at all other sites, in the spirit of McConnell et al. (1995), the present analysis uses ordinary least squares (OLS) to model individual anglers' catch rates as a function of other anglers' average catch rates, individual anglers' self-reported skill level, and individual anglers' membership status in a hunting or fishing organization (as a proxy for avidity). Expected catch per unit effort model results are displayed in table 4.

The low R-squared statistic may raise a red flag regarding omission of key variables. However, fishing success is inherently random, where even skilled anglers will often catch no fish. Although there are obviously causes of this variability, the causes may be truly random from the perspective of the angler.

Furthermore, using this model provides more information than simply applying average catch rates to all anglers' expectations. Finally, predicted catch rates are within one standard deviation of reported catch rates for 308 of the 353 (87%) anglers whose data was used for this model. This model is used to generate expected catch rates for all anglers at all sites which, along with the site-specific variables described in table 4, is used in a RNL of angler site choice (table 5). We believe the model is sufficient for our purposes of illustrating the empirical tractability of linking RNL and IO models.

The RNL results generally conform to predicted angler preferences (a priori). First, a higher travel cost is a deterrent to fishing at a particular site, while higher catch rates are an attractant. Surveyed anglers prefer fishing at lakes as opposed to rivers, potentially due to the fact that larger fish tend to grow in lakes. Surveyed anglers also prefer public sites to private sites. Higher elevation sites are preferred to lower elevation sites (likely due to scenic beauty), but higher elevation sites also imply a larger (negative) travel cost coefficient. Larger lakes are preferred to smaller lakes. A popular California fishing guidebook (Stienstra, 2008) has a ranking of all major California fisheries which incorporates the author's observed catch rates, fish size, and scenic beauty. However, results indicate a negative and significant response to the variables proxied in aggregate by this ranking system. This may be due to the fact that other variables in the model already capture some of the characteristics in this ranking. The ranking system may also not be an accurate

explanation of how the majority of anglers respond to those site characteristics. Finally, one variable, education, was included to allow for variation across

individuals for the “stay home” option. More highly educated individuals prefer to spend fewer days fishing.

**Table 2.** Variable descriptions

Variable	Description
<i>Utility Function for "Fishing" Nests</i>	
Travel Cost	Round trip travel distance indicated by linear distance from zip code center of site to home zip code center. This linear distance is then divided by .78, which is the average fraction of total distance (as indicated by questions about anglers' most recent trip) that the linear distance measures. Finally, this new distance is multiplied by individual anglers' per-mile expenditures, which averages to be \$.37 per mile. <sup>a</sup>
Expected Catch Per Unit Effort	Using data collected at 17 sites, model individual catch rates as a function of average catch rates, self-reported skill, hunting/fishing club membership status. Use this model to predict individual expected catch rates at all sites.
Lake	Whether the site was a lake or not. Other site types include ponds, rivers, and streams.
Private	Whether the site was privately owned.
Stienstra Ranking	Independent ranking based on fish abundance, fish size, and overall quality of fishery (including scenic beauty, etc.) Scale is from 1-10.
Elevation	Elevation, in feet, above sea level, added as a proxy for scenic beauty.
Elevation*Travel Cost	Elevation (in feet) divided by travel cost. This variable allows for a different travel cost coefficient for varying elevation levels.
Surface Acres	Only applicable to lakes and reservoirs, this measures the surface area of the water body in acres. The utility functions for rivers and streams does not include this variable.
Fishery Constant	Separate constant for each fishery from which data was collected.
<i>Utility Function for "Staying Home" Nest</i>	
Home Constant	Constant for “other than fishing” nest.
Education	Reported years of education.
<i>Inclusive Value (IV) Parameters (<math>\theta</math>)</i>	
Fishing Elsewhere	Dissimilarity of "fishing elsewhere" nest from other nests. Significantly different from other IV parameters means more dissimilar.
Mono County	Dissimilarity of "Mono County fishing" nest from other nests. Significantly different from other IV parameters means more dissimilar.
Staying Home	Fixed at 1.

<sup>a</sup>Opportunity cost of time is not included. Individuals’ time spent on-site at all sites is unknown, most sampled individuals who did report income (many did not) report full-time (i.e., inflexible) salaries, and many individuals are retired. Although assumptions could be made, for example, ignoring time spent on-site (or assuming 8 hours per day spent on-site), 1/3 of the wage rate for wage earners, given the extrapolation inherently necessary in this site-choice model these assumptions would be broad and strong. The result, however, of ignoring the opportunity cost of time is that subsequent welfare estimates are likely an underestimate of the welfare derived from a day trip. See Parsons (2003) for a discussion of including the opportunity cost of time in recreation demand models.

**Table 3.** Variable averages for Mono County sites.

Variable <sup>a</sup>	Bridgeport Reservoir	Convict Lake	Crowley Lake	Hot Creek	June Lake Loop	Mammoth Lakes
Travel Cost <sup>b</sup>	\$189.35 (\$242.67)	\$189.19 (\$235.10)	\$189.19 (\$235.10)	\$189.19 (\$235.10)	\$188.71 (\$238.42)	\$189.19 (\$235.10)
Expected Catch Per Unit Effort	0.75 (0.23)	0.85 (0.24)	0.84 (0.24)	0.96 (0.25)	0.81 (0.25)	0.86 (0.24)
Lake	1	1	1	0	1	1
Private	0	0	0	0	0	0
Stienstra Ranking	10	10	10	8	7	6
Elevation ( <i>feet</i> )	6453	7850	6781	6844	7654	8900
Surface Acres	2914	168	650	n/a	n/a <i>Consists of many lakes.</i>	n/a <i>Consists of many lakes.</i>

<sup>a</sup>Standard errors in parentheses.

<sup>b</sup>The average travel cost is nearly identical for all sites, since all sites reside in Mono County and only zip code distances were used. However, travel costs vary widely across individuals (although for any individual, travel costs are the same for any Mono County site). Furthermore, these are average travel costs to the site for all individuals, not only those who visited.

**Table 4.** Expected catch per unit effort.

Variable	Coefficient	Standard Error
Constant	0.19	0.20
Average CPUE	0.23	0.14*
Hunting/Fishing Club Member	0.35	0.14***
Self-Reported Skill	0.06	0.03**
R-squared	0.05	
F-statistic	6.59	
Prob (F-statistic)	0.0002	

\*\*\* Significant at the 1% Level

\*\*Significant at the 5% Level

\*Significant at the 10% Level

**Table 5.** RNL Model results.

Variable <sup>a</sup>	Coefficient	Standard Error
Travel Cost	-0.005	0.0002 ***
Catch Per Unit Effort	1.424	0.105 ***
Lake	0.184	0.050 ***
Private	-2.483	0.079 ***
Stienstra Guidebook Ranking	-0.298	0.029 ***
Elevation	0.0004	0.00004 ***
Elevation*Travel Cost	-0.000003	0.0000001 ***
Logged Surface Acres	0.201	0.028 ***
Home Constant	1.824	0.154 ***
Education Level (years)	0.135	0.006 ***
<hr/>		
Mono County IV Parameter ( $\theta$ )	0.011	0.001 ***
Other Fishery IV Parameter ( $\theta$ )	0.029	0.001 ***
Stay Home IV Parameter	0.050	Fixed Parameter
<hr/>		
Number of Observations	16,122	
McFadden Pseudo R-Squared	0.4542323	
Restricted Log Likelihood	-53,540.24	

\*\*\* Significant at the 1% Level; \*\*Significant at the 5% Level; \*Significant at the 10% Level.

<sup>a</sup>Dummy Variables were included for each surveyed site except one (17 sites in total), but are suppressed here for convenience.

### 4.3. Linking substitution behavior with economic impact analysis

Results from the RNL model described in section 4.2 can be used to simulate hypothetical alterations in fishery characteristics in Mono County. For example, a site closure can be simulated by raising travel cost to infinity for that site. Convict Lake is within the historic range of the critically endangered Mountain Yellow-Legged frog, and it also receives the least visitation among the six surveyed sites. Convict Lake may, therefore, be the first major site which is targeted for re-establishment of the endangered frog. Table 6 illustrates what would happen to visitation patterns after such a closure. 29,500 angler days will be lost from Convict Lake, but of those angler days, 23,000 are predicted to be shifted to other Mono County sites. As such, instead of losing 29,500 angler days, only 6,500 angler days will substitute out of the Mono County region. This translates to a -\$650,000 economic impact, versus the -\$2.9 million economic impact predicted by the more naïve model (with no substitution).

What if, in response to pressure from environmental groups, stocking were to cease at Convict Lake? Armstrong and Knapp (2004) found that at certain water bodies, populations of fish survived even after elimination of stocking programs. In other words, even though fish are not native to many lakes that are currently stocked, the lakes still provide adequate habitat and food supply to sustain breeding populations of fish. At a lake like Convict Lake, which receives weekly stocking, it is likely that catch rates would fall if stocking were to stop. Table 7 illustrates the effect of a hypothetical 50% reduction in catch rates at Convict Lake. Nearly half of the angler days originally spent at Convict Lake will be spent elsewhere. Of the 14,000 angler days lost at Convict Lake, 11,000 are shifted to other Mono County sites. Accounting for this substitution, the economic impact to Mono County is only -\$300,000 per year (as compared with a -\$1.3 million per year impact predicted when failing to account for substitution).

**Table 6.** Policy Scenario - Shut Down Convict Lake.

	Baseline Angler Days	After Policy Angler Days	Difference	Economic Impact to Mono County
Bridgeport Reservoir	45,815	49,238	3,423	\$340,762
<b>Convict Lake<sup>a</sup></b>	<b>29,518</b>	<b>0</b>	<b>-29,518</b>	<b>-\$2,938,815</b>
Crowley Lake	120,062	129,032	8,969	\$892,999
Hot Creek	50,781	54,575	3,794	\$377,701
June Lake Loop	61,533	66,130	4,597	\$457,670
Mammoth Lakes	30,097	32,346	2,248	\$223,857
Net to Mono County	337,807	331,320	-6,487	-\$645,827
Other Fishery Days	3,812,579	3,814,047	1,468	n/a
Non Fishing Days	13,034,946	13,039,965	5,019	n/a
Days Spent Outside Mono County	16,847,525	16,854,012	6,487	n/a

<sup>a</sup>Closed or Reduced-Stocking sites indicated with **bold** in table.

**Table 7.** Policy Scenario - Reduce Catch by 50% at Convict Lake.

	Baseline Angler Days	After Policy Angler Days	Difference	Economic Impact to Mono County
Bridgeport Reservoir	45,815	47,305	1,490	\$148,367
<b>Convict Lake</b>	<b>29,518</b>	<b>16,593</b>	<b>-12,925</b>	<b>-\$1,286,798</b>
Crowley Lake	120,062	123,968	3,905	\$388,810
Hot Creek	50,781	52,433	1,652	\$164,450
June Lake Loop	61,533	63,534	2,001	\$199,269
Mammoth Lakes	30,097	31,076	979	\$97,467
Net to Mono County	337,807	334,910	-2,897	-\$288,435
Other Fishery Days	3,812,579	3,813,234	656	n/a
Non Fishing Days	13,034,946	13,037,188	2,241	n/a
Days Spent Outside Mono County	16,847,525	16,850,422	2,897	n/a

<sup>a</sup>Closed or Reduced-Stocking sites indicated with **bold** in table.

## 5. Conclusion

This paper demonstrates how revealed preference behavioral models can be used to estimate the final demand changes that drive input-output models in order to better inform economic impact analysis. Results indicate that failure to account for substitution patterns across recreational fisheries can result in gross overestimation of economic impacts of both site closure and of changes in site quality.

Several implications can be drawn from these results. First, future economic impact studies should be cautious when assuming that closure of a particular site (in the context of recreation demand) or

construction of a new amenity (in the context of urban development) will result in a complete exodus or influx of all economic activity that accrues to that site.

Second, very few studies exist which evaluate the regional economic impacts of changes in site attributes. This may be due to the fact that correctly accounting for substitution effects resulting from said changes can require more intensive data collection methods or due to the fact that, quite simply, few methods have been developed to account for these effects in the context of impact analysis. However, as many urban development and recreation management policies involve changes in quality (e.g.,

policies regarding inland fisheries involve bag limits, terminal tackle restrictions, and/or fish stocking; urban development policies involve improvement of current infrastructure), the ability to measure the economic impacts of such changes is critical.

Although the RUM can be used to augment traditional impact analysis, one major shortcoming of this model is that the estimated coefficients indicate the effects of marginal changes in attributes on the overall likelihood of visiting a site (this is true for any cross-sectional specification of the RUM). As such, future researchers may consider estimating random utility models for data that is collected at different times in order to reflect the varying marginal effects of attributes at varying levels (see Loomis and Cooper, 1990).

Finally, a shortcoming more general to input-output analysis is that statements regarding the economic "impact" of a certain policy action are more or less statements of a new static equilibrium. Over time, even if an industry (or a fishery) is shut down, individual producers (or retailers) can substitute to new business activities. The present analysis evaluates substitution in final demand, but does not account for dynamic substitution in production. Furthermore, substitution in production may lead to new in-region demand, which the present analysis also does not address. As such, the present analysis is more appropriate for short-run impacts than long-run impacts.

Still, the method presented in this study provides a straightforward way to incorporate substitution in final demand and make predictions about consumers' response to management alternatives in a timely manner without requiring a large time series of data. Furthermore, the results of this case study indicate that failing to account for these substitutions can result in estimates of economic impacts that are up to 4.5 times their true value. Although results may be more profound for other regions and other activities, the current study indicates that failing to pay attention to substitution could lead to gross misinterpretation of the potential economic effects of alternative management regimes.

## References

- American Sportfishing Association [ASA]. 2008. Sportfishing in America: An Economic Engine and Conservation Powerhouse. Report funded by the Multistate Conservation Grant Program, supported with funds from the Wildlife and Sportfish Restoration programs and jointly managed by the Association of Fish and Wildlife Agencies and the USFWS.
- Armstrong, T.W., and R.A. Knapp. 2004. Response by trout populations in alpine lakes to an experimental halt to stocking. *Canadian Journal of Fisheries and Aquatic Sciences* 61:2025-2037.
- Arrow, K., R. Solow, P.R. Portney, E.E. Leamer, R. Radner, and E. H. Schuman. 1993. Report of the NOAA Panel on Contingent Valuation. Report to the General Counsel of the US National Oceanic and Atmospheric Administration, Resources for the Future, Washington, DC.
- Bastian, C. 2004. Using Random Utility Models to Incorporate Substitution When Estimating Economic Values and Impacts of Closing a Unique Recreation Site: The Case of Snowmobiling in Yellowstone. Dissertation, Department of Agricultural and Resource Economics, Colorado State University.
- Bergstrom, J.C., R.J. Teasley, H.K. Cordell, R. Souter, and D.B.K. English. 1996. Effects of reservoir aquatic plant management on recreational expenditures and regional economic activity. *Journal of Agricultural and Applied Economics* 28:409-422.
- Coates, D., and B.R. Humphreys. 2000. The stadium gambit and local economic development. *Regulation* 23(2):15-20.
- Cordell, H.K., J.C. Bergstrom, G.A. Ashley, and J. Karish. 1990. Economic effects of river recreation on local economics. *Water Resources Bulletin* 26:53-60.
- Criddle, K. R., M. Herrmann, T. S. Lee, and C. Hamel. 2003. Participation decisions, angler welfare, and the regional economic impact of sportfishing. *Marine Resource Economics* 18:291-312.
- Deisenroth, D.B., and C.A. Bond. 2010. The Economic Contribution of the Private, Recreation-Based Aquaculture Industry in the Western United States. Final Report to the Western Regional Aquaculture Center.
- Fish and Game. 2010. Fish Planting Information. <<http://www.dfg.ca.gov/fish/hatcheries/fishplanting/Evaluation.asp>> Accessed July, 2011.
- Haab, T.C., and K.E. McConnell. 2002. *Valuing Environmental and Natural Resources: The Econometrics of Non-Market valuation (New Horizons in Environmental Economics)*. Edward Elgar Publishing.
- Hamel, C., M. Herrmann, S.T. Lee, K.R. Criddle, and H.T. Geier. 2002. Linking sportfishing trip attributes, participations, and regional economic impacts in Lower and Central Cook Inlet, Alaska. *The Annals of Regional Science* 36:247-264.

- Hensher, D.A., J.M. Rose, and W.H. Greene. 2005. *Applied Choice Analysis: A Primer*. Cambridge University Press.
- ICF Jones and Stokes. 2010. Hatchery and Stocking Program Environmental Impact Report/Environmental Impact Statement. Prepared for the California Department of Fish and Game and the United States Fish and Wildlife Service.
- Johnson, R.J., M.H. Ranson, E.Y. Besedin, and E.C. Helm. 2006. What determines willingness to pay per fish? A meta-analysis of recreational fishing values. *Marine Resource Economics* 21:1-32.
- Knapp, R.A., D.M. Boiano, and V.T. Vredenberg. 2007. Removal of nonnative fish results in population expansion of a declining amphibian (Mountain Yellow-Legged Frog, *Rana muscosa*). *Biological Conservation* 135:11-20.
- Loomis, J.B. 2006. Use of survey data to estimate economic value and regional economic effects of fishery improvements. *North American Journal of Fisheries Management* 26:301-307.
- Loomis, J.B., and J. Cooper. 1990. Comparison of environmental quality-induced demand shifts using time series and cross-section data *Western Journal of Agricultural Economics* 15:83-90.
- Markin Consulting. 2006. Report on the Economic Impacts of the Lane Events Center, Eugene, Oregon. Final Report.
- Martin Associates. 2009. Economic Impact Analysis of Northport Parking Garage Phase IV Structural Improvements. Report to the Broward County Port Everglades Department.
- McConnell, K.E., I.E. Strand, and L. Blake Hedges. 1995. Random utility models of recreational fishing: Catching fish using a Poisson process. *Marine Resource Economics* 10:247-261.
- MIG, Inc. 1997. IMPLAN System (2008 data and software). Stillwater, MN. <[www.implan.com](http://www.implan.com)>, Accessed July, 2011.
- Miller, R.E., and P.D. Blair. 2009. *Input-Output Analysis: Foundations and Extensions*. Cambridge University Press, Cambridge, MA, USA.
- Mono County Department of Economic Development & Special Projects [Mono]. 2009. The Economic & Fiscal Impacts and Visitor Profile of Mono County Tourism in 2008. <[www.monocounty.ca.gov/departments/economicdevelopment/econdev.html](http://www.monocounty.ca.gov/departments/economicdevelopment/econdev.html)> Accessed July, 2011.
- Morey, E.R., W.S. Breffle, R.D. Rowe, and D.M. Waldman. 2003. Estimating recreational trout fishing damages in Montana's Clark Fork River Basin: Summary of a natural resource damage assessment. In *The New Economics of Outdoor Recreation*. Edward Elgar Publishing.
- Morey, E.R. 1999. Two RUMs uncloaked: nested logit models of site choice and nested logit models of participation and site choice. In *Valuing the Environment Using Recreation Demand Models*. (C.L. Kling and J.A. Herriges, Eds.), Edward Elgar Publishing Ltd.
- Morey, E.R., R.D. Rowe, and M. Watson. 1993. A repeated nested-logit model of Atlantic salmon fishing. *American Journal of Agricultural Economics* 75:578-592
- Murphy J.J., P.G. Allen, T.H. Stevens, and D. Weatherhead. 2005. A meta-analysis of hypothetical bias in stated preference valuation. *Environmental and Resource Economics* 30:313-325
- Parker, D. 1994. Inyo National Forest Amphibian Status Report. U. S. Forest Service, Bishop, California Office.
- Parsons, G. 2003. The travel cost mode. In *A Primer on Non-Market Valuation*. Kluwer Academic Publishers.
- Steinback, S.R. 1999. Regional economic impact assessment of recreational fisheries: an application of the IMPLAN modeling system to marine and charter boat fishing in Maine. *North American Journal of Fisheries Management* 19:724-736.
- Stienstra, T. 2008. *Moon California Fishing: The Complete Guide to Fishing on Lakes, Streams, Rivers, and the Coast*. Avalon Travel Publishing
- US Census. 2009. Mono County Quick Facts. <<http://quickfacts.census.gov/qfd/states/06/06051.html>> Accessed July, 2011.
- Watson, P., J. Wilson, D. Thilmany, and S. Winter. 2007. Determining economic contributions and impacts: what is the difference and why do we care? *Journal of Regional Analysis and Policy* 37(2):140-146
- Weiler, S., J. Loomis, R. Richardson, and S. Schwiff. 2003. Driving regional economic models with a statistical model: possibilities for hypothesis tests on economic impacts. *Review of Regional Studies* 32:97-111.
- Weiler, S., and A. Seidl. 2004. What's in a name? extracting econometric drivers to assess the impact of national park designation. *Journal of Regional Science* 44:245-262.