

**♪ Happy (Hypothetical) Trails to You:**

**The Impact of Trail Characteristics and Access Fees on  
a Mountain Biker's Trail Selection and Consumer's Surplus<sup>1</sup>**

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Abstract

Approximately thirty million North Americans own mountain bikes, and three million of them are avid trail riders. Some consequences are trail degradation and conflicts with other users. Resource managers often respond by closing trails and/or entire sites to mountain biking. When mountain biking is allowed, it is often on four-wheel drive roads rather than the narrow single-track trails many bikers prefer.

The impact of such changes on mountain bikers is evaluated by developing and estimating a random utility model that predicts the effects of trail characteristics, access fees, and characteristics of the individual on trail selection. The model is used to estimate an individual's per-trip compensating variation associated with changes in site characteristics and/or access fees. These CV's vary as a function of household budget and other characteristics of the individual. The model also estimates how site selection will change if site characteristics and/or access fees change. Results indicate that bikers have significant willingness to pay for trail quality.

Estimation is with stated preference data. Specifically, a set of hypothetical mountain bike trails was created and each surveyed biker was asked to make five pair-wise choices. Focus groups were used to identify relevant site and user characteristics. Three hundred individuals completed the survey at the Portland Bike Show.

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Mountain biking is currently one of the fastest growing outdoor recreation activities in the nation. According to the Bicycle Institute of America, 25 million Americans owned mountain bikes in 1992, a 66% increase from 1990. The Executive Director of the International Mountain Bicycling Association (IMBA, 1994), estimates that there are 2.5 - 3 million avid trail cyclists in the nation today. The growing popularity of mountain biking is also evident through the increased use of public lands by mountain bikers. For instance, the 13-mile Slickrock Trail in Moab, Utah was used by 1,000 mountain bikers in 1983; ten years later it was ridden by over 90,000 (IMBA, 1994).

Important consequences of the growing popularity of mountain biking in many areas have been increased trail degradation and conflicts among users on single-track trails. These trails, which are usually 12-24 inches wide, are preferred by many mountain bikers over wider four-wheel drive roads for their greater technical and physical challenge. Resource managers have typically handled trail degradation and user conflict by closing certain trails or entire sites to mountain biking. For example, in March of 1995, The City Council of Redmond, Washington voted to ban mountain bikes from the city's Watershed Preserve Area over concerns of environmental damage (Sprung, 1995).

In cases where land managers have not closed entire sites to cyclists, they have often moved mountain bikers from narrow, technical, single-track trails to wider, less technical, double-track. For instance, in 1992 the National Park Service imposed comprehensive restrictions on mountain bike use in the 13,000-acre Headlands area of Golden Gate National Recreation Area in Marin County, California, the birth place of modern mountain biking. The restrictions closed about one-third of the land to mountain bikes and banned mountain bikes from most of the single-track trails, leaving primary fire roads for mountain biking (Kelley, 1994).<sup>2</sup> Boulder Colorado, a city with hundreds of miles of trails, has banned bikes from most of those trails.

Due to the differences in the speed at which mountain bikers, equestrians, and hikers travel along single-track trails, conflicts arise: bikers must slow down, and hikers and equestrians often need to get out of the way. Land managers often respond to these conflicts by banning or restricting mountain bikes, often at the request of hiking groups (Blumenthal, 1994). Because increased management has meant not only a change in the quantity of sites available but also the quality of sites, a "characteristics approach" to site-choice behavior is necessary to gain a complete understanding of the welfare effects associated with changes in the availability and quality of mountain biking trails.

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<sup>2</sup>The Bicycle Trails Council of Marin and the International Mountain Bicycling Association filed suit against National Park Service in 1992, following the implementation of the restrictions.

The sensitivity of mountain bikers to the introduction of access fees needs to be evaluated. This is an important and controversial topic, made topical by the growing demands on public lands to provide multiple services. The introduction of access fees on public lands is a likely reality in light of the shrinking budgets to manage public lands.<sup>3</sup> Revenues from the access fees paid by mountain bikers may become an important factor in the provision and maintenance of trails. Access fees might also make private sites profitable.

In response, a discrete-choice random-utility model of mountain bike site-choice is developed and estimated that predicts the effects that trail characteristics and access fees have on trail selection. Focus groups were used to identify relevant site and user characteristics. Estimation is with stated preference data. Specifically, a set of hypothetical mountain bike trails was created and each surveyed biker was asked to make five pair-wise choices. The individual's choice decision is a function of trail characteristics, household budget, other characteristics of the individual, presence of other users, and access fees.

Individual estimates of per-ride willingness to pay and/or willingness to accept are derived for changes the site characteristics and the introduction of an access fee at a popular mountain bike site near Boulder, Colorado. Results indicate that bikers have significant willingness to pay for trail quality. Estimates of how changes in access fees and site characteristics will affect site choice are also derived. This is information needed by managers of public lands that are attractive to mountain bikers. Such estimates could also determine whether a private mountain bike site could charge a fee high enough to make a profit.

### **I. A Discrete Choice Random Utility Model of Mountain Bike Site Choice**

Assume that the mountain biker's site-choice decision is represented by a discrete choice random utility model in which individual  $i$  chooses mountain bike site  $j$  that provides the greatest utility, where site  $j$  is a member of a  $J$ -alternative choice set,  $C_{iJ}$  available to individual  $i$ . The utility individual  $i$  receives from riding his mountain bike at site  $j$  is

$$(1) U_{ij} = V_{ij} + \varepsilon_{ij}, \text{ where } V_{ij} \text{ is assumed deterministic from both the researcher's and the individual's point}$$

of view. The component  $\varepsilon_{ij}$  of utility is random from the researcher's perspective, but known by the individual.  $U_{ij}$

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<sup>3</sup>The 1996 Interior Appropriation bill included authorization for a three-year recreation fee demonstration program. This program directs the US Forest Service, Bureau of Land Management, Fish and Wildlife Service and National Park Service to create a variety of projects to collect fees from recreationists who use facilities on public lands (Sprung 1996).

is conditional indirect utility, because it is maximum utility conditional on the choice of site.  $V_{ij}$  is a function of the trail characteristics of site  $j$ , characteristics of individual  $i$ , and the access fee at site  $j$ .

For individual  $i$ , maximum utility from a mountain bike ride is

$$(2) \quad U_i \equiv \max(U_{i1}, U_{i2}, \dots, U_{iJ}) = \max(V_{i1} + \varepsilon_{i1}, V_{i2} + \varepsilon_{i2}, \dots, V_{iJ} + \varepsilon_{iJ})$$

and is known to the individual. Individual  $i$  will choose site  $j$  if  $U_{ij} \geq U_{ik} \forall k \in C_{iJ} \rightarrow U_i = U_{ij}$ .

Assuming that each  $\varepsilon_{ij}$  is independently drawn from a univariate Extreme Value Distribution (McFadden, 1974),

with distribution function  $F(\varepsilon) = \exp(-e^{-\varepsilon})$ , the probability that individual  $i$  will choose to ride at site  $j$  is given

by the multinomial logit model

$$(3) \quad Prob(ij) = \frac{e^{V_{ij}}}{\sum_{k=1}^J e^{V_{ik}}}$$

The multinomial logit model imposes the independence of irrelevant alternatives (I.I.A.) property; that is, the ratio of any two probabilities is independent of any change in any third alternative (McFadden, 1974). I.I.A. allows the parameters calculated from choices among pairs of sites to be generalized to choice sets with any number of alternatives.

$V_{ij}$  is a function of a vector of the trail characteristics,  $Z_j$ , defining site  $j$ ; the amount of money the individual has left to spend on all other goods after choosing to ride at site  $j$ ; and other characteristics of individual  $i$ ,  $S_i$ . Expenditures for all other goods is the individual's daily budget less the access fee at site  $j$ ,

$(Budget_i - Fee_j)$ . Therefore,

$$(4) \quad V_{ij} = V(Z_j, S_i, (Budget_i - Fee_j)) \quad i = 1, 2, \dots, I. \quad j = 1, 2, \dots, J.$$

The vector  $S_i$  consists of common socioeconomic variables such as age and gender in addition to variables which describe individual  $i$ 's interest in mountain biking and his or her cycling skill. The estimated model assumes that budget affects site choice and is therefore an *income-effects* model.<sup>4</sup> A sufficient condition for the model to include income effects is for the term  $(Budget_i - Fee_j)$  to enter  $V$  in some nonlinear manner.

## II. The Benefits and Costs of a Stated Preference Approach

Modeling and estimating recreational site-choice behavior requires that for each individual the researcher must be able to identify the sites in the individual's choice set, identify the cost to the individual of a trip to each of these sites, and list and quantify the characteristics of each site that affect site-choice. Site identification, travel costs, and site characteristics have been studied for years for such activities such as fishing and downhill skiing, the study of mountain bike site choice is new, and there are new difficulties.<sup>5</sup> These issues can be controlled and studied by asking respondents to choose the preferred alternative from a small set of hypothetical sites, with each choice set depicting different cost and characteristic tradeoffs.

Consider a site to be a system of interconnected single and double-track trails open to mountain bikes, but not to cars. Such sites tend to be well defined, but specifying the cost of traveling to them is problematic. Mountain bikers can always drive to the trail head, but in many cases they can also bike to the site, and which mode of transportation they choose will often vary from trip to trip.<sup>6</sup> Because of this, travel costs to the same site can vary extensively across individuals and, for a given individual, from ride to ride as a function of the individual's time constraints and preferences for riding on the road. Such variations in costs are important but difficult for the researcher to measure. The problem of estimating travel costs can be avoided if one restricts the analysis to hypothetical sites, because the researcher can specify the road type and distance to each of the sites. We make the simplifying assumption that the sites are all the same short distance from the individual's residence, so travel is immaterial and individuals make their choices solely on the basis of site characteristics and access fees. This allows

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<sup>4</sup>See Morey (1998) for a discuss of income effects in logit and nested logit models.

<sup>5</sup>When we started this paper in 1994, we thought we were first to study trail selection by bikers. However, Louviere *et al* (1991) developed and estimated a model of bike trail choice in Chicago. Since then, Fix and Loomis (1997) have used contingent valuation and a travel-cost count model to estimate the benefits of mountain bike trips to Moab Utah. Neither study consider the specific impact of access fees on site selection.

<sup>6</sup>Economists who develop and estimate travel-cost models have always been concerned with whether the individual gets utility from the trip to the recreational site, but have tended to push the issue to the background because the trip involves an activity that is typically different from the activity produced at the site. One does not fish his or her way to the fishing site or ski to the downhill ski area. So, for such applications it is common to assume the trip is solely part of the cost of producing the activity.

us to investigate the impact of access fees on site-choice without the added complication of travel costs. A stated-preference technique is advantageous for several additional reasons. Mountain biking in the real world involves both participation and site-choice decisions. A stated-preference approach allows us to easily separate the site-choice decision from the participation decision. The initial goal of this research is to predict where individuals go mountain biking, rather than whether they go.

Another advantage of a stated preference technique is that it allows the individual to “experience” greater variation in site-choice than exists in the real world. Independent variation in trail characteristics across sites is necessary to estimate the influence of trail characteristics on site-choice. With hypothetical sites, sufficient variation can always be generated. For example, the influence of access fees on site-choice cannot be estimated with only data on actual sites because there is not sufficient variation in access fees across sites: most sites are currently free.<sup>7</sup> But the impact of fees can be estimated by varying access fees across hypothetical sites.

Potential problems exist with the use of contingent behavior data. Most significantly, there is no guarantee that individuals will actually do what they state they will do. Observed behavior (revealed preferences data) involves commitment and opportunity cost, while stated preferences do not. There is much ongoing research on the reliability of consumer's surplus estimates based on stated preference data rather than revealed preference data, the calibration of such estimates, and on combining stated and revealed preference data to obtain better estimates.

### III. Survey Design: Hypothetical Choice Experiments

Stated preference data was obtained using hypothetical choice experiments; specifically, mountain bikers chose their preferred site from each of five pairs of hypothetical sites.<sup>8</sup> Choice experiments require the respondent to choose his or her most preferred alternative (a partial ranking) and typically includes price (cost) as one of the

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<sup>7</sup>To our knowledge, there are only a few sites in the U.S. that specifically charge mountain bikers for trail use. One is the Catamount Family Center in Wiliston Vermont. The Catamount Center is a winter nordic ski area and like many nordic areas charges skiers for trail access. Nordic trails often make good mountain bike trails. Downhill areas typically charge hikers and mountain bikes a fee to take a lift to the top of the mountain, but do not charge if one is willing to peddle or walk up. The Bureau of Land Management charges to park at the trail head for the Slick Rock Trail in Moab Utah, but since the trail head only a mile from town, this is not an access fee per se. However, we expect fees to increase. See footnote 3.

<sup>8</sup>Choice experiments are a type of conjoint analysis. Conjoint experiments require respondents to rank alternatives or rate alternatives using a cardinal scale. Conjoint analysis developed in marketing and transportation research to analyze preferences when little market data is available (e.g., Louviere 1988a and 1988b, and Hensher *et al.* 1988). Applications of conjoint techniques in marketing research have been mainly concerned with predicting the market share of consumer products (Louviere and Woodworth 1983). Conjoint analysis has been used to investigate a wide range of topics such as consumer preference toward electric cars (Beggs *et al.* 1981), improved visibility (Rae 1983), diesel odor (Lareau *et al.* 1989), farm-raised fish (Habrendt *et al.* 1991), the siting of noxious facilities (Opaluch *et al.* 1993), and farm land preservation (Kline and Wichelns 1996). Other applications to environmental valuation include Johnson *et al.* 1995, Roe *et al.* (1996) and Johnson and Desvousges (1997).

characteristics of the alternatives, so that the preferences towards the other attributes can be measured in terms of dollars. Studies that have used choice experiments to value non-market environmental commodities include Magat *et al.* (1988), Viscusi *et al.* (1991), Adamowicz *et al.* (1994), Adamowicz *et al.* (1996), Adamowicz *et al.* (1997), and Mazzotta (1997). Choice experiments that specifically value site-specific recreational activities include water-based site choice (Adamowicz *et al.* 1994 and Mathews *et al.* 1997), and moose hunting (Adamowicz *et al.* 1996 and Adamowicz *et al.* 1997).<sup>9</sup>

#### *The Mountain Bike Site Choice Experiment*

A set of six characteristics were identified to describe mountain bike sites. These six characteristics and their chosen discrete levels are listed in Table I. Interviews, focus groups, and personal experience was used to identify the relevant characteristics and their relevant ranges. Restricting the characteristics to discrete levels simplifies the creation of sites and choice sets. Even with the discrete levels listed in Table I, there are 486 ( $3^5 \times 2^1$ ) possible distinct sites.

However, many of these sites, while topographically possible, would not be considered mountain bike sites by most mountain bikers. For example, many of the possible sites would involve climbs too steep to ride. Experience and focus groups were used to screen unrealistic sites from the choice sets; focus group participants often balked at choice sets that included unrealistic sites. The goal was to create realistic choice sets with independent variation in the characteristic levels sufficient to accurately estimate the parameters on those characteristics. There is no need to include all 486 possible sites in the hypothetical choice sets.

Thirty-six realistic sites were created. They encompass wide variation in the levels of the six characteristics. Twelve of the 36 sites are identified in the Appendix. Fifty pair-wise choice sets were constructed by randomly pairing sites from the 36 sites, rejecting and replacing any pairings which displayed dominance.<sup>10</sup> This generated an orthogonal design.

Table I

List of characteristics used in the description of mountain bike sites.

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<sup>9</sup> In all of these choice experiments, respondents were presented with pairs or triplets of alternatives from which they chose their most preferred. In most of the studies, the status quo was included in at least some of the choice sets, and in all of the choice sets that had three alternatives.

<sup>10</sup> Dominance refers to a pairing in which one alternative is superior to another on every attribute or perhaps equal on every attribute except price, so that no tradeoffs are involved in selecting the alternative (Hensher *et al.*, 1988). Pairings displaying dominance were rejected, because, assuming rationality, they tell us nothing about the tradeoffs an individual makes in choosing a site.

<u>Characteristic</u>	<u>Values</u>
1. <i>Total length of trail</i>	7 miles 14 miles 21 miles
2. <i>Percentage of trail which is single-track</i>	0% 50% 100%
3. <i>Total vertical feet of climbing</i>	400 feet 1200 feet 2200 feet
4. <i>Number of peaks along trail profile<sup>11</sup></i>	1 peak 2 peaks 4 peaks
5. <i>Entrance fee</i>	\$1 \$5 \$8
6. <i>Used by hikers/equestrians</i>	YES NO

The 50 choice sets were blocked into ten sets, creating ten versions of the survey, each with five pairs. Choice sets were limited to five to ensure that an individual would give his or her full attention to each choice set and complete the survey. The focus groups demonstrated that individuals would have no difficulty making five pair-wise choices and explain in words each of those choices. Asking the individuals to explain their choices provides valuable additional information and encourages individuals to invest thought in the choice process. Data was also collected on the individual's interest and experience in mountain biking, gender, age, and monthly household budget.

Nonparticipation was not included as a third alternative. Because the goal is to evaluate where individuals go mountain biking when they do go, rather than whether they go, the absence of a non-participation option is appropriate. Debriefings after the focus groups indicated that individuals were comfortable with this question format. If an individual was unable to choose between two alternative, he or she had the option of not answering, but this was not encouraged.<sup>12</sup>

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<sup>11</sup> All climbs within a site are of the same length.

<sup>12</sup>For examples of experiments with non-participation options see Louviere and Woodworth (1983), Adamowicz *et al.* (1994) and Adamowicz *et al.* (1996). One might include non-participation (or *not sure*) as an option so the individual is not forced to make decisions when he is unwilling or unable to make a choice. However, individuals always have the option of not answering a question, and giving them *neither* as an alternative gives them an *easy out*, so makes it less likely they will choose when it is a tough choice, but choices when the individual is

The final survey (see Appendix A) is the result of the focus group discussions of three earlier versions of the survey. Focus groups were held with three cycling clubs in Boulder, Colorado. Members were asked to complete the survey and comment on anything that was confusing, unclear, or unrealistic. After each focus group completed the survey, the group was debriefed on the realism of the site descriptions, the presence of access fees, and the importance of trail characteristics included or omitted from the site descriptions. Including a trail profile map was a result of the focus group discussions.<sup>13</sup> It was also learned that the inclusion of free sites in choice sets was not a good practice; some individuals would always choose the free site independent of the quality of another site with an access fee. Mountain bikers are not accustomed to paying to ride, so this practice was likely a protest against access fees because in focus groups where the lowest fee was \$1 no one always chose the alternative with the lowest fee.

#### **IV. Data**

The data was collected at the Portland Bicycle Show on March 11 and 12, 1995. The Portland Bicycle Show is an annual consumer trade show where manufacturers and local bicycle shops exhibit their products. As individuals passed by a booth provided by the show, they were asked if they mountain biked, and if so, would they complete a survey about mountain biking. Individuals were informed that the survey would take about three to five minutes. Of the 326 individuals who responded that they rode a mountain bike, 92% agreed to complete the survey. Enough questions were answered and pair-wise choice made to generate a final data set with 289 individuals and 1172 choices.<sup>14</sup> Site A (the first site in the pairing) was chosen 54.65% of the time. 73% of the surveys included comments explaining site choices.

#### *Summary of Survey Data*

The sample is 81% male and 62% single; the average age is 30 years. In terms of experience, the majority of the respondents considered themselves intermediate mountain bikers, and 64% considered themselves primarily mountain bikers, rather than road riders or commuters. Respondents rode their bicycles an average of four days per week in the spring and summer. The average mountain bike owned by respondents was 2.5 years old and cost \$831. Forty percent of the respondents had mountain bikes equipped with suspension systems.

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close to indifference can reveal a lot about preferences.

<sup>13</sup> See the Appendix for examples of trail profiles.

<sup>14</sup> 289 is 73% of the individuals who responded that they rode a mountain bike and 97% of the individuals who agreed to take the survey. 1172 is 81% of the pair-wise choice presented to these 289 individuals; not all respondents answered all five pairings.

### *Construction of Individual Daily Budget*

In order to estimate a model of site-choice which includes income effects, an individual daily budget was calculated for each respondent. The survey asked the question, “How much does your household spend on housing, food, transportation, clothing, and entertainment in a typical month?” Individuals were presented with five budget categories and asked to choose the one which best described their household monthly budget. The median of each category was used in the calculation of individual daily budget. The average monthly household budget was \$1178. Individuals were also asked if they were married and how many children they had. This information was used to ascertain the number of individuals in the home, assuming that the respondent’s children live in his or her home. The individual daily budget was calculated in the following way:

$$(5) \quad budget = \frac{Monthly \ Household \ Budget}{(Number \ in \ Household)(365 \ days/12 \ months)}$$

## **V. Empirical Results**

### *Estimation*

The indirect utility functions  $V_{iA}$  and  $V_{iB}$  are assumed to be a function of the variables defined below.

Focus group comments and the experience of the researchers indicated that these variables are important determinants of trail selection.

$fee_j$  = Required entry fee for trail access at site  $j$

$dist_j$  = Total miles of the trails at site  $j$

$str_j$  = The miles of single-track trail at site  $j$

$vfc_j$  = Total vertical feet of climbing at site  $j$

$peaks_j$  = The total number of peaks along the trail profile at site  $j$

$hiker_j$  = 1 if site  $j$  is used by hikers and equestrians, otherwise 0

$budget_i$  = Daily household budget

$gender_i$  = 1 if individual  $i$  is male, 0 if female

$mtb'er_i$  = 1 if individual  $i$  considers him/herself a mountain biker, otherwise 0

$train_i$  = 1 if individual  $i$  considers a mountain bike ride to be training, otherwise 0

$susp_i$  = 1 if individual  $i$  has a suspension system on his/her mountain bike, 0 if not

The estimated conditional indirect utility function is.<sup>15</sup>

$$(6) \quad V_{ij} = \beta_1(dist_j) + \beta_2(dist_j)^5 + \beta_3(dist_j)(vfc_j) + \beta_4(vfc_j) + \beta_5(gender_i)(vfc_j) + \beta_6(vfc_j)(peaks_j) \\ + \beta_7(peaks_j) + \beta_8(str_j) + \beta_9(str_j)(susp_i) + \beta_{10}(hiker_j) + \beta_{11}(budget_i-fee_j) \\ + \beta_{12}(budget_i-fee_j)(train_i) + \beta_{13}(budget_i-fee_j)(mtb'er_i) + \beta_{14}((budget_i-fee_j)^5)$$

The parameter estimates are reported in Table II. The model correctly predicts 64% of actual choice behavior. All parameter estimates have plausible signs, and are for the most part are precisely estimated as evidenced by their large t-ratios. The total impact of each included variable is supported by a likelihood ratio test. For example, the null hypothesis that *vfc* has no effect ( $\beta_4 = \beta_5 = \beta_6 = 0$ ) is rejected.

The null hypothesis of no-income effects is rejected at a ten percent level of significance. The marginal utility of money is a function of the individual's budget, whether a mountain bike ride is for training, and whether the individual considers himself a mountain biker. The marginal utility of money declines as household budget increases, so the more affluent are less sensitive to fees. Looking ahead, variation in the marginal utility of money is a major determinant of why per-trip compensating variations vary across individuals. Increased access fee has a negative impact on site choice for almost all of the individuals in the sample, but the magnitude of that impact varies across individuals because of the differences in their marginal utility of money. Individuals who consider themselves mountain bikers and/or on a training ride have, *ceteris paribus*, a lower marginal utility of money, so are less sensitive to fees.

Summarizing the influence of site characteristics, *single-track* has a positive effect on site-choice, which is stronger if the individual owns a mountain bike with a suspension system. Considering the popularity of single-track riding among mountain bikers, the positive sign on single-track is not surprising. Single-track trails are usually rougher than other types of trails, accounting for the positive relationship between the ownership of a suspension system and single-track. In light of documented conflict between hikers/equestrians and mountain bikers, it is not surprising that the presence of hikers and equestrians has a highly significant negative impact on site-choice.

Table II  
Maximum likelihood parameter estimates of model.

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<sup>15</sup>The use of a linear functional form in parameters is quite conventional in the discrete choice literature. See Louviere and Woodworth (1983), Morey (1981), Morey, Rowe, and Watson (1993), Adamowicz et al. (1994), and (1996). Seven dollars was added to each individual's daily budget in the term (*budget<sub>i</sub>-fee<sub>j</sub>*) to ensure that this variable was not an imaginary number for individuals with very low budgets.

<u>Parameter</u>	<u>Estimate</u>	<u>t-Ratio</u>
$\beta_1$	0.4369	2.905**
$\beta_2$	-2.6553	-2.674**
$\beta_3$	-0.0484	-2.877**
$\beta_4$	0.1150	0.415
$\beta_5$	0.4212	2.701**
$\beta_6$	0.1766	3.008**
$\beta_7$	-0.0420	-0.489
$\beta_8$	0.0335	1.887*
$\beta_9$	0.0378	2.971**
$\beta_{10}$	-0.7405	-7.046**
$\beta_{11}$	0.0579	0.699
$\beta_{12}$	-0.0787	-2.543**
$\beta_{13}$	-0.0415	-1.202
$\beta_{14}$	0.9639	1.687*

\* Significant at a 10% level of significance.

\*\* Significant at a 5% level of significance.

The interpretation of the other parameters is less straightforward. For the trail characteristics which enter the conditional indirect utility function in nonlinear ways, they can, as a function of their level and the level of other characteristics, have either a positive or negative effects on site-choice. For example, the effect of increasing distance depends on the amount of climbing at the site. Subject to the qualification that a site remains realistic, bikers prefer short-steep trails and longer-flatter trails to those in between in terms of grade and length. For a site with a 1000 vertical feet of climbing, decreasing distance makes the site more attractive if total trail length is less than 11.75 miles, but increasing trail length makes the site more attractive if total trail length is greater than 11.7 miles. For a site with 500 (2000) feet of climbing, the point where increasing distance becomes attractive is 10.5 (15.2) miles. Vertical feet of climbing and trail length largely determine the difficulty of a trail but difficulty is not monotonically increasing in either vertical feet of climbing or trail length, and more difficulty is good but only up to a point.

The preference for short-steep trails and longer-flatter trails to those in between can also be seen by examining how site attractiveness changes when the amount of climbing increases. For example, for a trail with two peaks, increasing the amount of climbing will make the site more attractive to a male rider if the trail is less than 18.38 miles, but less attractive if the trail is more than 18.38 miles. In contrast the break point is 9.45 miles for females.

Increasing the number of peaks on a trail makes the site more attractive if the site has more than 238 vertical feet of climbing and less attractive if the site has less climbing. Rolling hills are an attractive feature; one

gets to climb and then recover on the downhill before the next climb, but "rollers" need to be of a sufficient height before they become a positive feature.

### *Probability Elasticities*

How responsive individuals are to changes in site characteristics and access fees is best represented with estimates of how much the probability of choosing a site changes when the level of a site characteristic or access fee increases. For example, assume that there are only two mountain bike sites available to the residents of Boulder, Colorado: White Ranch (*W*) and the Sourdough Trail (*S*), both popular sites. For simplicity further assume each site is the same distance from each individual's residence.<sup>16</sup> Given these assumptions and the current trail characteristics of White Ranch and the Sourdough trail, the model predicts, if given the choice between White Ranch and the Sourdough trail, 62% of trips will be to White Ranch.<sup>17</sup> Probability elasticities for White Ranch for changes in the variables *dist*, *vcf*, *str* and *fee* are all inelastic, and respectively -.27 (-.37 to -.16), .24 (-.17 to .49), .19 (.08 to .37), and -.18 (-.45 to -.04).<sup>18</sup> The numbers in parentheses are the within-sample range on the estimated elasticities. Elasticities vary across individuals as a function of gender, daily budget, and interest in mountain biking.

## **VI. Per-Ride Compensating Variations for Changes in Site Quality and/or Access Fee**

Continue with the simplifying assumption that there are only two mountain bike sites: White Ranch (*W*) and the Sourdough trail (*S*), and consider the per-ride compensating variation individual *i* associates with proposed change in the trail characteristics and/or access fee at one or both of these sites.<sup>19</sup> Denote the initial state  $(Z^0, Fee^0)$  and the proposed state  $(Z^1, Fee^1)$ .

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<sup>16</sup> Differences in travel costs could be accounted for by adding travel costs to the access fee.

<sup>17</sup>For White Ranch *dist* = 15.4 miles, *str* = 10.3 miles, 3000 *vcf*, 3 *peaks*, used by hikers and equestrians, and no use fee. For the Sourdough Trail, *dist* = 12 miles, *str* = 12 miles, 1550 *vcf*, 2 *peaks*, used by hikers and equestrians, and no use fee (Rich 1993)

<sup>18</sup>The elasticity estimates with respect to fee are calculated at the baseline levels for the two sites except with a \$4 access fee at White Ranch, elasticities with respect to *fee* cannot be calculated when there is no access fee at either site.

<sup>19</sup>Note that the model does not restrict the choice set to two sites. Two sites is just the simplest example.

The per-ride compensating variation individual  $i$  associates with this change,  $PRCV_i$  is the amount of money that when subtracted from the daily budget in the proposed state makes maximum utility in the proposed state with this compensation equal to maximum utility in the original state. For example, if the proposed change is the introduction of an access fee at White Ranch, maximum utility either decreases or stays the same: utility decreases if the individual would choose White Ranch without the fee, and utility stays the same if the individual would ride the Sourdough trail with or without the fee at White Ranch.<sup>20</sup> Therefore, for a fee increase at White Ranch,  $PRCV$  is zero for those individuals who choose the Sourdough trail with or without the fee, the negative of the fee for those individuals who choose White Ranch both with and without the fee, and between zero and the negative of the fee for those individuals who would choose White Ranch before the fee is introduced but not afterwards.

Alternatively, if the proposed change is an increase in trail quality at White Ranch, the  $PRCV$  is nonnegative and is equal to how much the individual would pay per-ride for this increase in trail quality. It will be zero for all those individuals who would not choose White Ranch with the quality improvement.

An individual's  $PRCV$  multiplied by the number of rides he or she currently takes in a year is a lower bound estimate of the individual's yearly  $CV$  for the change. For details see Morey (1994 and 1998)

Denote the maximum utility individual  $i$  receives in the initial state  $U_i^0$ , where

$$(11) \quad U_i^0 \equiv \max(U_{iW}^0, U_{iS}^0) = \max(V_{iW}^0 + \varepsilon_{iW}, V_{iS}^0 + \varepsilon_{iS})$$

and denote the maximum utility individual  $i$  receives in the proposed state with compensation,  $c$ , subtracted from the daily budget

$$(12) \quad U_i^1(c) \equiv \max(U_{iW}^1(c), U_{iS}^1(c)) = \max(V_{iW}^1(c) + \varepsilon_{iW}, V_{iS}^1(c) + \varepsilon_{iS})$$

If  $c = 0$ , this collapses to the maximum utility individual  $i$  receives in the proposed state; that is

$$(12a) \quad U_i^1 \equiv U_i^1(c=0) \equiv \max(U_{iW}^1, U_{iS}^1) = \max(V_{iW}^1 + \varepsilon_{iW}, V_{iS}^1 + \varepsilon_{iS})$$

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<sup>20</sup>Note that no one who chooses the Sourdough trail when there is no fee at White Ranch would switch to White Ranch when it has a fee.

The  $PRCV_i$  associated with a change from  $(Z^0, Fee^0)$  to  $(Z^1, Fee^1)$  is the  $c$  that equates  $U_i^1(c)$  and  $U_i^0$ .

$PRCV_i$  cannot be observed - it depends on the unobserved  $\varepsilon_i$ .

The  $PRCV$  will vary across individuals for two reasons: the  $(V_{iW}, V_{iS})$  vary across individuals as a function budget, gender, type of ride, etc., and for individuals with the same  $(V_{iW}, V_{iS})$ , the  $(\varepsilon_{iW}, \varepsilon_{iS})$  vary. The

$PRCV$  for a given individual will also vary across trips because the  $(\varepsilon_{iW}, \varepsilon_{iS})$  vary across trips. Denote all individuals who have the same  $(V_{iW}, V_{iS})$  as individuals of the same *type*.

For a given proposal, each individual has a specific  $PRCV$  but from the researcher's perspective the  $PRCV$  for an individual is a random variable with some density function,  $f(PRCV)$ , that depends on the individual's *type*. Denote the expected value of the  $PRCV$  for individuals of a given type,  $E(PRCV)$ . It is not possible to directly calculate  $E(PRCV)$  when there are continuous income effects but it can be approximated.<sup>21</sup> A

good approximation is the  $PRCV$  for the *representative* individual,  $PRCV^R$ , where  $PRCV^R$  is the monetary compensation (or payment) in the proposed state that would make the expected maximum utility in the proposed state equal to the expected maximum utility in the initial state.<sup>22</sup> That is,  $PRCV_i^R$  is that  $c$  for which

$$E(U_i^0) = E(U_i^0(c)), \text{ where } E(U_i) = \ln(e^{V_{iW}} + e^{V_{iS}}) + .577. \quad E(U_i) \text{ is the utility of a representative}$$

individual in that it is maximum utility if  $\varepsilon_{Wi} = \varepsilon_{Si} = 0$ .  $PRCV_i^R$  is the random-utility analog of the standard

<sup>21</sup>The approximation can be made as accurate as needed using a technique outlined by McFadden (1996), but that technique is computationally burdensome.

<sup>22</sup>Note that the representative individual varies by *type*. With numerical and empirical examples, Hanemann (1985) and Herriges and Kling (1997) find that  $CV^R$  often closely approximates the  $E(CV)$ . McFadden uses a numerical example to demonstrate that the bias can be as much as 30% for policies that cause very large changes in utility. For a detailed discussion of these issues, see Hanemann (1985), McFadden (1996), Herriges and Kling (1997) and Morey (1998)

definition of the compensating variation in terms of a continuous utility function. There is not a closed-form solution for  $PRCV_i^F$  but it can be calculated numerically.

$PRCV_i^F$  are estimated for each of four possible changes in quality/access fees at White Ranch. The four proposals considered are:

1. The introduction of a four dollar access fee at White Ranch.
3. Prohibiting the use of White Ranch by hikers and equestrians.
2. Banning mountain bikers from all single-track trails at White Ranch.<sup>23</sup>
4. The conversion of the 5.1 miles of double-track trails at White Ranch into single-track trails, funded by a five dollar access fee.

These estimates are summarized in Table III. The model predicts that individuals would have to be paid, on average, \$2.40 per-ride to accept a \$4 access fee at White Ranch. The presence of Sourdough Trail in the choice set causes the  $PRCV_i^F$  to be greater than -\$4 because some individuals choose the Sourdough trail even before the \$4 access fee is introduced at White Ranch and some individuals will switch to the Sourdough trail because of the fee. When the introduction of a \$5 access fee is accompanied by an improvement in site quality, as in *proposal 4*, some respondents are better off, while others are worse off. The estimated  $PRCV_i^F$  range from -\$24.48 to \$17.23. A \$5 access fee accompanied by converting all of the trails at White Ranch to single track (*proposal 4*) would pass a referendum vote.<sup>24</sup>

Table III  
Site-choice probabilities and estimated  $PRCV_i^F$   
for the four White Ranch proposals\*

<u>Change in Quality and/or Fee</u>	<u>Statistic</u>	<u>Prob. of choosing WR</u>	$PRCV_i^R$
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<sup>23</sup>This will reduce the total mileage by seven miles, total vertical feet of climbing by 1,365 feet, and number of peaks by one.

<sup>24</sup>Assume everyone with a greater than .5 estimated probability of choosing White Ranch in the proposed state voted yes. Interestingly, the proposal passes in spite of the fact that the median of the  $PRCV_i^F$  is negative.

Remember that  $PRCV_i^F \neq PRCV_i$

0. Initial State.	mean	0.623	N/A.
	median	0.642	N/A.
	range	0.493 to 0.657	N/A.
1. Introduction of \$4 access fee at WR	mean	0.540	-\$2.40
	median	0.557	-\$2.45
	range	0.333 to 0.664	-\$2.91 to \$-1.69
2. Prohibiting hikers and equestrians at WR.	mean	0.774	\$7.49
	median	0.790	\$5.70
	range	0.671 to 0.800	-\$47.94 to \$31.00
3. Closing all single track trails at WR.	mean	0.414	-\$9.24 (\$4.98)
	median	0.451	-\$5.64
	range	0.343 to 0.460	-\$38.13 to 20.48
4. All single-track trails and \$5 fee at WR.	mean	0.577	-\$0.25
	median	0.591	-\$1.49
	range	0.328 to 0.728	-\$24.48 to \$17.23

\*The range is the within-sample range on the  $PRCV_i^r$ .

The closure of White Ranch to hikers and equestrians generates strong positive welfare effects for most mountain bikers, illustrating the negative impact these two groups have on mountain bikers. Individuals, on average, would pay an estimated \$7.49 to have hikers and equestrians prohibited from White Ranch - running over hikers is not welfare improving.<sup>25</sup>

The estimated  $PRCV_i^r$  for the closure of all single-track at White Ranch illustrate the importance mountain bikers place on single-track. On average, individuals would accept the closure of all single-track at White Ranch for a per-ride payment of \$9.24. One reason the closure of single-track trails has such large negative effects on welfare is that such an action changes the magnitude of other variables as well. For example, closing the single-track at White Ranch reduces the trail distance by seven miles.

As illustrated in Table IV, the  $PRCV_i^r$  vary across individuals as a function of gender and interest in mountain biking. An individual who considers himself a mountain biker, regards a mountain bike ride as training, and owns a bicycle with a suspension system could be viewed as a serious mountain biker. Holding income constant, those who are more involved experience greater impacts due to changes in site quality.

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<sup>25</sup>This makes one wonder what hikers would pay to have the mountain bikes banned.

For each proposal, individuals of *type 2* (serious mountain bikers) have the largest  $PRCV^F$  in absolute terms, and casual cyclists (*type 1*) have the smallest. Serious mountain bikers also take the most rides. Individuals of *type 2* and *type 3* would be expected to vote for *proposal 4*, casual cyclists would not.

Ceteris paribus,  $PRCV^F$  varies across individuals depending on the level of their daily budget.

Figure I indicates that  $PRCV^F$  for a deterioration in site quality (*proposal 3*) is a decreasing function of daily budget; that is, individuals with larger budgets need to be paid more to accept a quality decrease.

In contrast consider *proposal four*: it involves both a fee increase and a conversion of double track into single track. *Proposal 4* makes casual cyclists worse off. Figure II indicates that the amount that the casual cyclist must be paid to accept this deterioration is a decreasing function of his or her daily budget; that is, casual cyclists who are affluent need to be paid less to accept the change than do casual cyclists who are poor. This is in contrast to WTA for *proposal 3*, where WTA is increasing in income. The difference results because both poor and affluent are equally and positively impacted by the conversion of double track to single track, but the affluent are less negatively impacted by the fee increase. All casual cyclists are made worse off by *proposal 4* but poor ones more.

Table IV  
Site-choice probabilities and estimated  $PRCV_i^r$  for the four White Ranch proposals  
for four *types* of individuals

<u>Individual</u>	<u>variable</u>	<u>initial state</u>	<u>Scenario</u>			
			<u>#1</u>	<u>#2</u>	<u>#3</u>	<u>#4</u>
1. Casual Cyclist*	prob.	0.509	0.381	0.685	0.450	0.390
	CV		\$-1.79	\$3.41	\$-0.87	\$-1.67
2. Serious Mountain Biker <sup>+</sup>	prob.	0.641	0.632	0.790	0.351	0.710
	CV		\$-2.71	\$24.49	\$-13.59	\$11.96
3. Road Rider**	prob.	0.656	0.608	0.800	0.460	0.636
	CV		\$-2.56	\$9.97	\$-9.68	\$-1.11
4. Weekend Mountain Biker <sup>++</sup>	prob.	0.493	0.405	0.671	0.343	0.472
	CV		\$-1.82	\$4.85	\$-3.01	\$-0.45

Budget is held constant across the individuals at the sample mean of \$39.26.

\* Casual Cyclist:  $mtb'er=0, train=0, gender=0, susp=0$ .

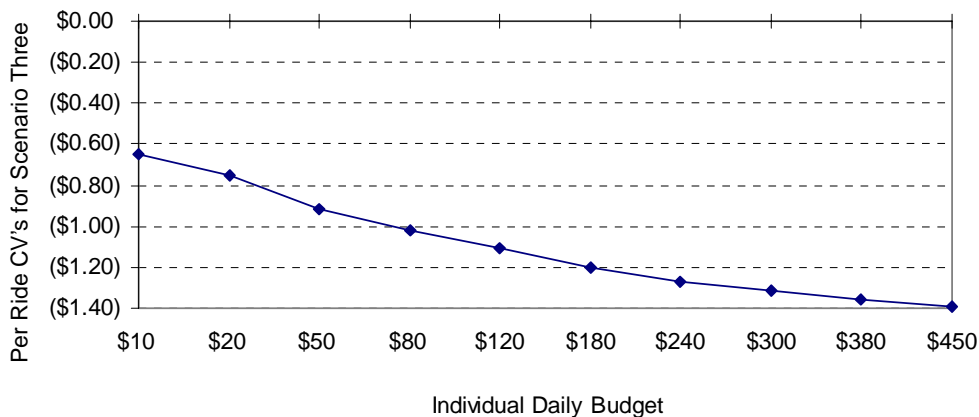
++ Weekend Mountain Biker:  $mtb'er=1, train=0, gender=0, susp=1$ .

+ Serious Mountain Biker:  $mtb'er=1, train=1, gender=1, susp=1$ .

\*\* Road Rider:  $mtb'er=0, train=1, gender=1, susp=0$ .

Figure I.

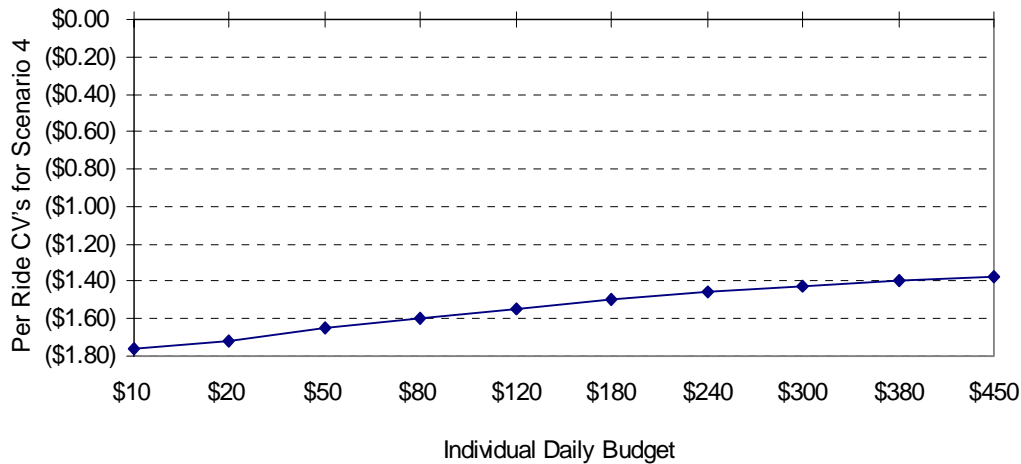
$PRCV^r$  for scenario 3 for a casual cyclist as a function of the individual's daily budget.\*



\*All  $PRCV^r$  values are negative.

Figure II.

$PRCV^r$  for scenario four for a casual cyclist as a function of the individual's daily budget.\*



\*All  $PRCV^r$  values are negative.

## VII. Concluding Remarks

The use of hypothetical discrete choice experiments is an emerging technique for estimating amenity values. This study indicates one can develop realistic and policy relevant choice sets with such experiments, and, as others have shown with different examples, derive estimates of WTA and/or WTP for changes in the characteristics of recreational sites.<sup>26</sup> The mountain bikers in our sample displayed reasonable and plausible behavior while choosing between pairs of hypothetical sites. The consumer surplus estimates varied across individuals quite plausibly in terms of household budget, gender and interest in mountain biking. When contingent behavior experiments are designed well, they can provide powerful results for analyzing the management of environmental amenities.

The results have important implications for the management of mountain biking. The estimated model indicates that many mountain bikers would be willing to accept access fees for either a new site or an improved site. Access fees are one way to keep trails open that might otherwise be closed to mountain bikers. In the case of contact with hikers and equestrians, mountain bikers would prefer to pay to ride if it meant that they would not

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<sup>26</sup>See Adamowicz *et al.* (1994) and Adamowicz *et al.* (1996).

encounter hikers or equestrians. The magnitude of the  $PRCV_i^r$ s for the closure of single-track at White Ranch indicates that land managers should not take such actions lightly.

The result that mountain bikers would be willing to pay access fees for new or improved sites is based on stated preferences rather than revealed behavior, so one must question whether mountain bikers will really pay what the estimated model indicates; they might actually pay less or more. To answer this question, one needs access fees at mountain bike sites in the real world.

Estimation of our model with a combination of revealed preference data and actual observed behavior would strengthen the model and also provide information as to how stated behavior might or might not differ from actual behavior. The inclusion of travel costs in such a model would allow one to investigate whether individuals' actual responses to travel costs are similar to their stated reactions to access fees.

A next step in modeling the site-choice behavior of mountain bikers is the inclusion of the participation decision. The inclusion of the participation decision would make the model more complete and therefore provide per-season, rather than per-ride, willingness to pay and willingness to accept estimates.

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## Appendix A

**Mountain Biking Survey****Personal Information**

Age: \_\_\_\_\_ Gender: M F

**Mtn. Biking Experience:**

Novice Intermediate Advanced

**Do you consider yourself more a:**

Road Rider Mountain Biker

**Have you ever raced bicycles?**

YES NO

**If "Yes," in what category (Sport, Cat. 3, etc.)?**

NORBA \_\_\_\_\_ USCF \_\_\_\_\_

**How many days do you ride in a typical spring/summer week (road and mtn.)? \_\_\_\_\_****Do you consider a Mtn. Bike ride training or an outing?**

Training Outing

**Do you have a suspension system (Rock Shox, Flex Stem, etc.)? YES NO****Do you have clipless pedals on your Mtn.****bike (SPD's, Onza, Look, etc.)? YES NO****How much did you pay for your Mtn.****bike? \_\_\_\_\_****How many years ago did you purchase****your bike? \_\_\_\_\_****Choice of Mountain Bike Site**

In the next section you will be asked to consider pairs of mountain bike sites. The sites are defined by a profile and a short list of attributes. Assume the two sites in each set are the only mountain biking opportunities available to you. Please keep in mind the following: All sites are five miles from your home. All trails are loops. The sites are double-track or jeep road except for the indicated miles of single-track. Attributes not described in the survey such as scenery or trail condition are the same at all sites. All trailheads are at an elevation of zero feet.

Each pairing should be considered independent of all others.

*The survey then included drawings of single-track and double-track.*

We have few more important questions that will greatly aid our analysis. Please note that this survey is completely confidential.

**Marital Status: Single Married****If you have children, how many do you have? \_\_\_\_\_****How much does your household spend on housing, food, transportation, clothing, and entertainment in a typical month?**

&lt; \$800 \$800 - \$1200 \$1200 - \$1600 \$1600 - \$2000 &gt; \$2000

**What is your hourly wage? If you are not currently employed, what would you expect your hourly wage to be if you were working? \_\_\_\_\_**