Estimating the benefits and costs to mountain bikers of changes in trail characteristics, access fees, and site closures: choice experiments and benefits transfer

Edward R. Morey[*], **Terry Buchanan and Donald M. Waldman**

Department of Economics, Campus Box 256, University of Colorado, Boulder CO 80309-0256, USA

Mountain biking is an increasingly popular leisure pursuit. Consequences are trail degradation and conflicts with hikers and other users. Resource managers often attempt to resolve these problems by closing trails to mountain biking. In order to estimate the impact of these developments, a model has been devised that predicts the effects of changes in trail characteristics and introduction of access fees, and correlates these with biker preference on trail selection. It estimates each individual's per-ride consumer's surplus associated with implementing different policies. The surplus varies significantly as a function of each individual's gender, budget, and interest in mountain biking. Estimation uses stated preference data, specifically choice experiments. Hypothetical mountain bike trails were created and each surveyed biker was asked to make five pair-wise choices. A benefit-transfer simulation is used to show how the model and parameter estimates can be transferred to estimate the benefits and costs to mountain bikers in a specific area.

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Introduction

Tens of millions of North Americans and Europeans own mountain bikes and millions of them are avid trail riders. In the 1990s mountain biking was one of the fastest growing outdoor recreational activities. 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), estimated that in 1994 there were 2·5–3 million avid trail riders in the US. The numbers are much larger 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

1000 mountain bikers in 1983; 10 years later it was ridden by over 90 000 (IMBA, 1994).

The growing popularity of mountain biking in many areas has led to increased trail degradation and conflicts among users on single track. 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. The conflicts arise because mountain bikers travel at speeds much greater than those of hikers and equestrians. Bikers must slow down, and hikers and equestrians often need to get out of the way.

Resource managers have often 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 due to concerns of environmental damage (Sprung, 1995).

[*] Corresponding author. Email: Edward.Morey@Colorado.edu

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Often the closures are at the request of hiking groups (Blumenthal, 1994).

In cases where land managers have not closed entire sites to mountain bikers, they have often moved mountain bikers from narrow, technical, single-track trails to wider, less technically challenging, 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 birthplace of modern mountain biking. The restrictions closed about one-third of the land to mountain bikes and banned them from most of the single-track trails, leaving primary fire roads for mountain biking (Kelley, 1994).[1] Boulder, Colorado, a city with thousands of bikers and hundreds of miles of trails, has banned bikes from most of them.

Access fees are being increasingly discussed as tools of land use management. This is an important and controversial subject, 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.[2] 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.

Whether trail closures and access fees lead to more or less efficient use depends on the benefits and costs to the different user groups. As a step in estimating these benefits and costs, a discrete-choice random-utility model of mountain bike site-choice has been developed 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 employed stated preference data. A set of hypothetical mountain bike trails was created and each individual asked to make five pairwise choices (choice experiments). 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. The model and choice experiments can be used as a template to estimate benefits and costs to other users from land use policies.

A simulation demonstrates how the model and parameter estimates can be used to assess the benefits and costs to mountain bikers of changes in specific sites. In the example, two sites are assumed; the per-ride consumer's surplus is derived for changes in the first site's characteristics, including the introduction of an access fee. While these estimates can be used to assess the benefits and costs of a policy in a specific area, in our example the consumer's surplus cannot be transferred. Its magnitude depends on the characteristics of the choice set in the region of interest.

Louviere *et al*. (1991) developed and estimated a model of bike trail choice in Chicago. Fix and Loomis (1998) have used contingent valuation and a travel-cost count model to estimate the benefits of mountain bike trips to Moab, Utah. Neither study considered the specific impact of access fees on site selection, although Fix and Loomis found significant willingness to pay for access.

A discrete choice random utility model of mountain bike site choice

Assume the utility individual i receives from riding his mountain bike at site j is

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (1)$$

where V_{ij} is assumed to be deterministic from both the researcher's and the individual's perspective. Given J sites to choose from, the individual chooses the site the maximizes his or her utility from the ride. The component ε_{ij} of utility is random from the researcher's perspective, but known by the individual. Assume that all the ε_{ij} are independent draws from an Extreme Value distribution. The result is a simple logit model of site choice.

V_{ij} is a function of a vector of the trail characteristics, Z_j, defining site j; the amount of money the individual has budgeted for all other goods after choosing to ride at site j, and other characteristics of individual i, S_i. The daily budget less the access fee at site j is represented by $(Budget_i - Fee_j)$. Therefore,

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

The vector S_i consists of common socioeconomic variables such as age and gender, in addition

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[1] 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.
[2] The 1996 Interior Appropriation bill included authorization for a 3-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 collects fees from recreationists who use facilities on public lands (Sprung, 1996).

to those which describe individual i's interest in mountain biking and his or her cycling skill. The model assumes that budget affects site choice and is therefore an *income-effects* model.[3] 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. Note that most sites are currently free, so there is insufficient variation in the real world price to estimate the effect of price on site choice.[4]

Survey design: the choice experiments

Stated preference data were obtained using choice experiments; specifically, mountain bikers chose their preferred site from each of five pairs of hypothetical sites.[5] Choice experiments require the respondent to choose his or her most preferred alternative (a partial ranking) and typically include price (cost) as one of the characteristics of the alternatives, so that the preferences towards the other attributes can be measured in terms of money.

In this application, the respondent did not have the option of choosing 'none of the above'. Nonparticipation was also not included as a third alternative. For a discussion of the benefits and costs of including these options, see Morey (2001). Debriefings after the focus groups indicated that individuals were comfortable with this question

format. Given the absence of a nonparticipation alternative, the data can be used to estimate the consumer surplus per ride, but not per year. This is because no information is obtained about the desired frequency of rides given the chosen site, only whether the biker would prefer site A or B. It can be assumed that a rider will not ride less if a site is improved, or more if it deteriorates. One can therefore use the per-ride measures to put bounds on consumer surplus, bounds that are policy relevant in this context. This is discussed in more detail below.

Studies that have used choice experiments to value environmental commodities include Magat *et al.* (1988), Viscusi *et al.* (1991), Adamowicz *et al.* (1994), Mazzotta (1997) and Morey *et al.* (2001). Choice experiments that specifically value site-specific recreational activities include water sports (Adamowicz *et al.*, 1994; Mathews *et al.*, 1997), moose hunting (Adamowicz *et al.*, 1996, 1997), and fishing sites (Breffle *et al.*, 2001).

The mountain bike site choice experiment

A set of six characteristics was identified to describe mountain bike sites (listed, together with their chosen discrete levels, in Table 1). Interviews, focus groups, and personal experience were used to identify relevant characteristics and ranges. The vast majority of mountain bike trails have

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[3] See Morey (1999) for a discuss of income effects in logit and nested logit models.

[4] To our knowledge, there are only a few sites in the US that specifically charge mountain bikers for trail use. One is the Catamount Family Center in Wiliston, Vermont, a winter nordic ski area which, 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 pedal 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 is only a mile from town, this is not an access fee per se. However, we expect fees to become more common. See footnote 2.

[5] Choice experiments are a type of conjoint analysis, developed as part of marketing and transportation research to analyze preferences when few market data are available (e.g. Louviere, 1988a,b; Hensher *et al.*, 1988). Applications 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 electric cars (Beggs *et al.*, 1981), improved air quality (Rae, 1983), diesel odor (Lareau *et al.*, 1989), farmed 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).

Table 1. List of characteristics used in the description of mountain bike sites

Characteristic	Values
1. Total length of trail	7 miles 14 miles 21 miles
2. Percentage of trail that is single track	0% 50% 100%
3. Total vertical feet of climbing	400 feet 1200 feet 2200 feet
4. Number of peaks along trail profile*	1 peak 2 peaks 4 peaks
5. Entrance fee	US$ 1 US$ 5 US$ 8
6. Used by hikers/equestrians	YES NO

*All climbs within a site are of the same length.

physical characteristics within these ranges. Focus group participants helped identify 36 realistic sites with wide variation in the levels of the six characteristics. Fifty pair-wise choice sets were constructed by randomly pairing sites from the 36 sites, replacing any pairings which displayed dominance. This generated a design that presented sites that were realistic and a set of choice pairs that had sufficient independent variation in the variables and their interactions to estimate the impact of each characteristic on site choice.

The 50 choice sets were blocked into ten sets, creating ten different 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 explaining 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 were also collected on each individual's interest and experience in mountain biking, gender, age, and monthly household budget. Sample survey with one of the five choice questions, is included in Appendix. The final survey was the result of the focus group discussions of three earlier versions. 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 group completed the survey, it 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.

All of the sites in the pairs included an access fee. While a significant number of cyclists in the focus groups expressed displeasure about the fees, in debriefings most indicated that they could choose between the alternatives even if they disliked both of them. Individuals completing the survey could still tell us which alternative they disliked the least.

More information about the cyclists' preferences could have been obtained by generalizing the choice questions in a number of ways. After each pair, the individual could have been asked whether the site they chose is better or worse than some site (perhaps their favorite) in their actual choice set. That is, have the individual rank their chosen alternative relative to an existing site. One could also ask a follow-up participation question to determine how much an individual thinks he or she would use the site they chose.

Both of these possible extensions to the survey would have significantly increased its complexity and made the data more difficult to model. Having the respondent compare their choice to a status quo site would have required surveys that varied by location, since the survey would have to name and list the characteristics of that site. The underlying model would also have to explain participation and site choice. Since this is a first application of choice experiments to estimate the preferences of mountain bikers, we chose to stay simple. This simplification does not come without costs. The results of the model cannot be used to predict how much, if at all, a mountain biker would increase, or decrease, his number of rides to a site if its characteristics change. This has important implications for welfare economics. From our data, one can derive consumer surplus per biking day, but not per year. However, these per-ride measures combined with data on the current number of days can often be used to place policy-relevant bounds on per year consumer surplus.

Data

The data were collected at the Portland Bicycle Show on March 11 and 12, 1995. Mountain bike trails in Oregon vary in terms of physical characteristics levels at least as much as the choice pairs. The Show is an annual event where manufacturers and local bicycle shops exhibit their products; it is widely attended by cyclists in the area. 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. They were informed that the survey would take about 3 to 5 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.[6] Site A (the first site in the pairing) was chosen 54% of the time; 73% of the surveys included comments explaining site choices. There is little in these comments to suggest that individuals were 'protesting' or answering in

[6] The total of 289 represents 73% of the individuals who responded that they rode a mountain bike and 97% of the individuals who agreed to take the survey, where 1172 is 81% of the pair-wise choice presented to these 289 individuals. Not all respondents answered all five pairings.

other strategic ways. In fact, most of the comments reflect the opposite. Some respondents always choose the alternative with the lesser access fee but this is to be expected. To the extent that some individuals strategically always choose the cheaper alternative, benefits may be underestimated and costs overestimated, although there is no evidence that this is happening.

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 4 days per week in the spring and summer. The average bike owned by respondents was 2·5 years old and cost US$ 831; 40% of the respondents had bikes equipped with suspension systems.

Bikers vary in terms of their observed characteristics such as age, gender, budget and road vs mountain biker. Individuals who were identical in terms of the individual characteristics included in the model were defined as bikers of a given *type*. While the sample was inexpensive to collect, one might expect that it was not representative in terms of type of biker. This is not an issue for parameter estimation as long as all types of bikers are adequately represented in the sample, which is the case here; to the extent that preferences vary by type, this is correctly incorporated into the model. The model allows preferences regarding site characteristics to vary as a function of factors such as age, gender, budget, road vs mountain biker, and whether one rides for training or fun. Our model includes all of these individual characteristics, and we find that preferences vary significantly according to type.

To obtain an estimate of population average consumer's surplus per ride for a particular policy, one needs to weight the consumer surplus estimate for each type of biker by the proportion of total rides taken by bikers of that type. This will be more fully explained below.

Construction of individual daily budget

In order to construct 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 which best described their household monthly budget. The median of each category was used in the calculation of individual daily budget. The average budget was US$ 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

$$budget=\frac{monthly\ household\ budget}{number\ in\ household)\\(365\ days/12\ months)}. \tag{3}$$

assuming the budget is equally divided among all family members.

Empirical results

Estimation

The utility function V_{ij} is 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:

$$V_{ij} = B_1(dist_j) + B_2(dist_j)^{.5} + B_3(dist_j)(vfc_j)$$
$$+ B_4(vfc_j) + B_5(gender_i)(vfc_j) + B_6(vfc_j)(peaks_j)$$
$$+ B_7(peaks_j) + B_8(str_j) + B_9(str_j)(susp_i)$$
$$+ B_{10}(hiker_j) + B_{11}(budget_i - fee_j)$$
$$+ B_{12}(budget_i - fee_j)(train_i) + B_{13}(budget_i - fee_j)$$
$$\times (mtb'er_i) + B_{14}((budget_i - fee_j)^{.5}) \qquad (4)$$

Note that site characteristics are allowed to have nonlinear effects and effects that vary as a function of the characteristics of the biker.[7] The maximum likelihood parameter estimates are reported in Table 2. Given the model and the variation in the sample in terms of significant individual characteristics, these estimates are asymptotically consistent and efficient for the population of mountain bikers at large, so can be used to make predictions about that population. However, as noted above, obtaining unbiased estimates of

Table 2. Maximum likelihood parameter estimates

Parameter	Estimate	t-ratio
B_1	0·4369	2·905**
B_2	−2·6553	−2·674**
B_3	−0·0484	−2·877**
B_4	0·1150	0·415
B_5	0·4212	2·701**
B_6	0·1766	3·008**
B_7	−0·0420	−0·489
B_8	0·0335	1·887*
B_9	0·0378	2·971**
B_{10}	−0·7405	−7·046**
B_{11}	0·0579	0·699
B_{12}	−0·0787	−2·543**
B_{13}	−0·0415	−1·202
B_{14}	0·9639	1·687*

*Significant at a 10% level of significance.
**Significant at a 5% level of significance.

[7] 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, 1996). Seven dollars was added to each individual's daily budget in the term $(budget_i - fee_j)$ to ensure that this variable was not an imaginary number for individuals with very low budgets.

average consumer surplus for a population will require that surplus by type be correctly weighted in terms of that type's representation in the population of rides.

The model correctly predicts 64% of the choices. All parameter estimates have plausible signs, and are for the most part 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 ($B_4 = B_5 = B_6 = 0$) is rejected.

The null hypothesis of no-income effects is rejected at a 10% level of significance. That is, income is an important determinant of how bikers value a policy change. Specifically, 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, as expected, the more affluent are less sensitive to fees. Looking ahead, variation in the marginal utility of money is a major determinant of why per-ride 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, all factors considered, 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, this is not surprising. Single-track trails are usually rougher than other types, 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. Bikers, as a rule, do not enjoy running into hikers or hitting horses.

The interpretation of the other parameters is less straightforward. For the trail characteristics which enter the 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 effect 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 1000 vertical of climbing and more than 11·7 miles of trail, increasing trail length makes the site more attractive. While, for a site with at least 15·7 miles of trail, increasing trail makes the site more attractive. A trail's level of difficulty does not increase monotonically in terms of either vertical feet of climbing or trail length. More difficult is good, but only up to a point.

The preference for short & steep and longer & flatter 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. 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 it has more than 238 vertical feet of climbing and less attractive if it has less. 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.

Benefit transfer: a policy simulation

The estimated preference parameters can cautiously be applied to mountain bikers who live in other regions with mountains or large hills.[8] In such areas, our model could be used to estimate, in part, how mountain bikers would value a change in the characteristic of a site or sites, including the addition of a new site or the elimination of an existing one. Here we present a simple example of how this could be done.

Note that the magnitudes of the consumer's estimates associated with any change in site characteristics are very dependent on the number of sites in the biker's choice set and their characteristics. The more good substitutes for a site, the less a biker will value a new site or an improvement in an existing one, and how one reacts to a access fee depends on the access fees, if any, at other sites. Therefore, policy implementation requires that all the existing sites be identified and measured in

terms of our six characteristics. Some of these data are often available in local guide books.

For our simple policy example, we assume bikers have a choice of just two sites: W and S. W has $dist=15.4$ miles, $str=10.3$ miles, 3000 vfc, 3 $peaks$, is used by hikers and equestrians, and has no use fee. S has $dist=12$ miles, $str=12$ miles, 1550 vfc, 2 $peaks$, is used by hikers and equestrians, and has no use fee. W and S correspond to two popular sites in Boulder, Colorado. The simulation also assumes that both sites are the same distance from town.[9] These assumptions will have significant impacts on the magnitude of derived welfare estimates.

If the choice set is as described, the model predicts 62% of rides will be to W; that is, it is slightly more popular than site S. One can also predict how the proportions will change if the site characteristics are changed. Proportions vary as a function of gender, daily budget, and interest in mountain biking.

Consider the per-ride compensating variation that individual i associates with a proposed change in the trail characteristics and/or access fee at one or both of these sites. The initial state is Z^0, Fee^0 and the proposed state Z^1, Fee^1. Compensating variation is an exact measure of consumer's surplus.

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 makes maximum utility in the proposed state equal to maximum utility in the original. It is negative or zero for a deterioration and positive or zero for an improvement. Put simply, it is what the individual would pay per ride for an improvement and, in absolute terms, what he would have to be paid, per ride, to accept a deterioration. The $PRCV$ will vary as a function of things the researcher can observe (budget, gender, etc.) and those he cannot (ε).

Consider, for example, the introduction of an access fee at W. Maximum utility either decreases or stays the same: it decreases if the individual chooses W without the fee, and stays the same if the individual rides S with or without the fee at W.[10] Therefore, for a fee increase at W, $PRCV$ is zero for those individuals who choose S with or without the fee, the negative of the fee for those

[8] Whether one transfers our parameter estimates or does new choice experiments is a budget issue.

[9] Differences in travel costs could be accounted for by adding travel costs to the access fee. This would require data on the distances to sites, mode of transportation, and value of time. Travel-cost data have been collected and used in travel-cost models for over fifty years.

[10] Note that no one who chooses S when there is no fee at W would switch to W when it has a fee.

who choose W both with and without the fee, and between zero and the negative of the fee for those who choose W before the fee is introduced but not afterwards.

Alternatively, if the proposed change is an increase in trail quality at W, the *PRCV* is non-negative and is equal to how much the individual would pay per ride for this increase in trail quality. It is zero for all those individuals who do not choose W with the quality improvement.

An individual's *PRCV* multiplied by the number of rides he or she currently takes to all sites in a year is a lower bound estimate of the individual's yearly *CV* for the change (Morey, 1994, 1999). That is, for an improvement the result is a floor on the benefits to the individual; for deterioration, the result is a ceiling (in absolute value) on damages. For an improvement, it is likely an underestimate because the improvement will likely cause him to ride more, and this is not accounted for in the calculation. For a deterioration, the individual's yearly *CV* is negative and *PRCV* multiplied by the current number of rides is, in absolute terms, the most he would have to be paid to accept the deterioration. It is an upper bound on damages because the individual will likely minimize the impact by reducing the amount he or she rides, and this is also not accounted for in the calculation.

For a given proposal, each individual has a specific *PRCV*. From the researcher's perspective, however, the *PRCV* is a random variable with a density function, $f(PRCV)$, that depends on the individual's *type*. The expected value of the *PRCV* for individuals of a given type can be denoted $E(PRCV)$. $E(PRCV)$ can be approximated using the representative individual approximation, $PRCV^r$, the monetary compensation (or payment) in the proposed state that would make the expected maximum utility in the proposed state equal to that in the initial state.[11] Specifically, $PRCV_i^r$ is the magnitude of c for which $E(U_i^0)=E(U_i^1(c))$, where $E(U_i^0)=\ln(e^{V_{iW}^0}+e^{V_{is}^0})+0.577$ and $E(U_i^1(c))=\ln(e^{V_{iW}^1}+e^{V_{is}^1})+0.577$ with c subtracted from the

budget in the proposed state. There is no closed-form solution for $PRCV_i^r$ but it can be calculated numerically.

$PRCV_i^r$ is estimated for each of four possible changes in quality/access fees at W:

(1) The introduction of a US\$ 4 access fee at W.
(2) Prohibiting the use of W by hikers and equestrians.
(3) Banning mountain bikers from all single-track trails at W.[12]
(4) The conversion of the 5·1 miles of double-track trails at W into single-track trails, funded by a US\$ 5 access fee.

The estimated $PRCV^r$s are listed by type of biker – four types are identified in Table 3: (1) casual cyclists, (2) serious mountain bikers, (3) road riders and (4) weekend mountain bikers. There are many more; these four were chosen as examples of distinct types. The estimated $PRCV_i^r$ vary significantly across these four types. An individual who considers himself a mountain biker, regards a mountain bike ride as training, and owns a bicycle with a suspension system is defined as a serious mountain biker. Holding income constant, those who are more involved experience the greatest impacts *per ride* caused by changes in site quality. They also take more rides.

New fees with no site improvement (Proposal 1) and eliminating single track (Proposal 3) make all bikers worse off, independent of type see Table 3. For example, the casual cyclist would have to be paid US\$ 1·79 per ride to accept their fee; remember that all of their rides are not to W. As required by theory, the $PRCV^r$ for Proposal 1 is between zero and US\$ −4 for every type of biker. It will decrease in absolute value as the number of other sites in the choice set increases. 0·381 is the probability that a casual cyclist would choose W for a ride if Proposal 1 were in place. It is also a function of the number of sites in the choice set.

Banning hikers and equestrians (Proposal 2) makes all bikers substantially better off. More single track, combined with a fee (Proposal 4) is positive for the serious mountain biker but negative for all other bikers. The variation in $PRCV^r$ across bikers for any of these four proposals is greater than the variation across the four types reported in Table 3. For example, for Proposal 4 the range is US\$ −24·48 to US\$ 17·23.

For each proposal, individuals of type 2 have the largest $PRCV^r$ in absolute terms, and casual

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[11] The approximation is exact when there are no income effects. Note that the representative individual varies by *type*. With numerical and empirical examples, Hanemann (1985) and Herriges and Kling (1999) find that CV^r often closely approximates the $E(CV)$. McFadden (1999) uses a numerical simulation to demonstrate that the bias can be as much as 30% for policies that cause very large changes in utility. To make sure the *PRCV* approximations are accurate, the per-ride $E(CV)$ were calculated for two policies (Proposals 1 and 2 below) using the more accurate, but computationally burdensome, McFadden simulation technique. $PRCV_i^r$ differed from the simulated $E(CV_i)$ by never more than 3%. For a detailed discussion of these issues, see Hanemann (1985), McFadden (1999), Herriges and Kling (1999) and Morey (1999).

[12] This will reduce the total mileage by 7 miles, total vertical feet of climbing by 1 365 feet, and number of peaks by one.

Table 3. Site-choice probabilities and estimated $PRCV_i^r$ for the four W proposals for four *types* of individuals

Individual	Variable	Initial state	Proposal			
			#1	#2	#3	#4
1. Casual cyclist*	prob.	0·509	0·381	0·685	0·450	0·390
	CV		US$ −1·79	US$ 3·41	US$ −0·87	US$ −1·67
2. Serious mountain biker+	prob.	0·641	0·632	0·790	0·351	0·710
	CV		US$ −2·71	US$ 24·49	US$ −13·59	US$ 11·96
3. Road rider**	prob.	0·656	0·608	0·800	0·460	0·636
	CV		US$ −2·56	US$ 9·97	US$ −9·68	US$ −1·11
4. Weekend mountain biker++	prob.	0·493	0·405	0·671	0·343	0·472
	CV		US$ −1·82	US$ 4·85	US$ −3·01	US$ −0·45

Budget is held constant across the individuals at the sample mean of US$ 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: $mtb'er=0$, $train=1$, $gender=1$, $susp=0$.

cyclists have the smallest. Note that while the signs would not change, all of these estimates would be smaller, in absolute terms, if additional sites were added to the choice set.

All other factors being equal, $PRCV^r$ varies across individuals depending on the level of their daily budget.

Figure 1 indicates that $PRCV^r$ 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 4: it involves both a fee increase and a conversion of double track into single track. Proposal 4 makes casual cyclists worse off. Figure 2 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. The difference results because both less and more affluent cyclists are equally and positively impacted by the conversion of double track to single track, although the more affluent are less negatively impacted by the fee increase. All casual cyclists are made worse off by Proposal 4 but the less affluent more so.

Aggregating to the biker population requires an estimate of what proportion of total rides are taken by each type or biker. Consider Proposal 4 and two extreme cases. If all of the rides in an area are taken by serious mountain bikers, Proposal 4 has large positive benefits. If they are taken by other types of bikers, the change has negative benefits. Given that a large percentage of rides are by serious mountain bikers, Proposal 4 will make bikers as a group better off, but many bikers worse off.
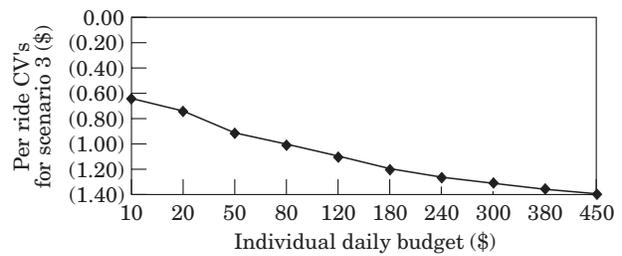

Figure 1. $PRCV^r$ for Proposal 3 for a casual cyclist as a function of the individual's daily budget. All $PRCV^r$ values are negative.
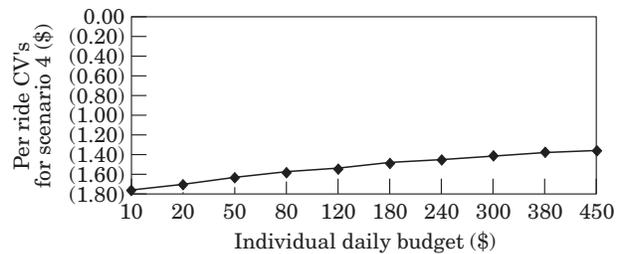

Figure 2. $PRCV^r$ for Proposal 4 for a casual cyclist as a function of the individual's daily budget. All $PRCV^r$ values are negative.

A sufficient condition for bikers as a group to be better off is

$$\frac{\sum R_t PRCV_t^r}{\sum R_t} > 0$$

where R_t is the number of rides taken to all sites by riders of type t. Remember that $PRCV^r$ underestimates benefits and overestimates damages. Therefore, one cannot conclude that bikers as a group are worse off if

$$\frac{\sum R_t PRCV_t^r}{\sum R_t} < 0.$$

Hikers and equestrians as well as bikers would be affected by the four policies considered. An access fee payable only by bikers will make other users as a group better off because it will reduce the overall demand for rides.[13] Such costs and benefits to other users need to be included in a cost benefit analysis. Choice experiments, based on our template, could be used to estimate the preferences of these other users.

Concluding remarks

Experiments were designed to estimate how mountain bikers would value changes in the characteristics of trails. The mountain bikers in our sample displayed reasonable and plausible behavior while choosing between pairs of hypothetical sites. The estimated parameters indicate more single-track is preferred, so is banning other users. Fees, by themselves, would be unwelcome. Trail difficulty is appreciated, but only up to a point. The consumer surplus estimates varied across bikers quite plausibly in terms of household budget, gender and interest in mountain biking. Willingness to pay is a function of income and interest in mountain biking. The results suggest that significant numbers of bikers would be willing to pay an access fee for improved conditions; the amount would depend on the number of substitute sites and the trail characteristics and fees, if any, at those sites.

A simulation was used to demonstrate how the parameter estimates could be used in a benefits transfer to value specific changes in the number of sites or the characteristics of existing sites.

The results have applicability beyond mountain biking. The study could be used as a template to estimate benefits and costs to other users (hikers and equestrians), a critical component of any analysis of the types of policies managers must consider.

Extensions, as discussed above, would include making the choice questions more complex, e.g. having the respondent compare their chosen alternative to an existing site in their choice set and/or asking how often the respondent would ride at the site if it had the conditions described. One could also combine the results of a simple survey such as ours with revealed preference data on existing sites (observed number of rides to each site in the choice set); that is, combine stated preference data

(choice experiments) with the data needed to estimate a travel cost model. This would allow one to estimate both participation (total number of rides) and site choice. In which case, one could estimate consumer's surplus rather than just a lower bound.

Acknowledgements

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[13] Other users who strongly prefer *S* to *W* could be made worse off as bikers shift rides from *W* to *S*.

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Appendix

Sample mountain biking survey

Personal Information

Age: _____   Gender: M   F

Mtn. Biking Experience:
Novice   Intermediate   Advanced

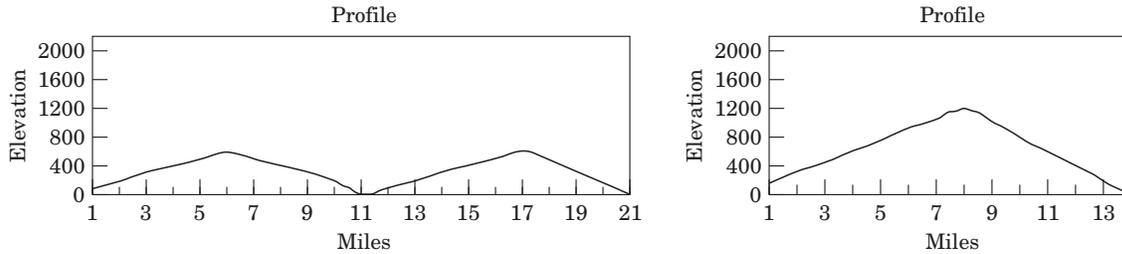Do you consider yourself more a:
Road Rider   Mountain Biker

Figure 3. Example of two site profiles.

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 a page with drawings
of single track and double-track. The survey then
included five pair-wise choice questions. These
varied across the ten versions of the survey. Figure 3
is an example of two site profiles:*

We have a few more important questions that
will greatly aid our analysis.
Marital Status: Single   Married
If you have children, how many do you have?

_____

How much does your household spend on hous-
ing, food, transportation, clothing, and entertain-
ment in a typical month?
US\$ <800 US\$ 800–US\$ 1200 US\$ 1200–US\$
1600 US\$ 1600–US\$ 2000 US\$ >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? _____

Thank you.