

Valuing the Impacts of Forest Fires on Backcountry Forest Recreation

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ABSTRACT. A discrete choice travel cost model was developed for backcountry forest recreation using 2 yr of backcountry canoe registrations from Nopiming Park, Manitoba. A statistically significant variable explaining choice of route was the amount of forest along the route that was burned in the last 10 yr; virtually all of which occurred in two particularly severe fires during 1983. The *current* economic welfare loss from these fires was estimated using a discrete choice travel cost model combined with a count model of trip demand. Since the forest grows back following fire, these losses will eventually decrease to zero. A linear intertemporal damage function for one of the fires is estimated, and the present value of damages under alternative discount rate assumptions is presented. *For. Sci.* 42(4):450–455.

Additional key words: Random utility, canoeing, count models.

A CONCERN IN FOREST MANAGEMENT is the risk of fire and the effects of fire on forest outputs, both timber and nontimber. While fire has been modeled in various forest management frameworks, little attention has been paid to the nonmarket economic impacts of fire damaged stands. Nonmarket impacts are important in a multiple use management context (Bowes and Krutilla 1985). Multiple use management suggests that fire management schemes should address fire damage to all outputs of the forest. This study examines the impacts of fire on nonmarket wilderness recreation values in a forested area of eastern Manitoba.

Previous work valuing wilderness canoeing by Hellerstein (1991, 1993) utilized both a simple and a panel single site count data travel cost model (TCM). These analyses developed estimates of the nonmarket value of recreation associated with the provision of a single wilderness area, the Boundary Waters Canoe Area in Minnesota. Hellerstein's studies do not value the characteristics of individual canoe route attributes in the wilderness park. In this study, we use information about individual use patterns of canoe routes in Nopiming Provincial Park in Manitoba to assess the value of recent fire damage.

In this analysis, a Multinomial-Poisson travel cost model is applied to canoeing in Nopiming Park, Manitoba. Canoeing is the predominant recreational activity in the area, and several designated routes are identified. Nopiming Park and surrounding areas were subjected to several large forest fires

in 1983. As a result, this park forms a natural experiment. In this experiment, canoeists choose among routes with different degrees of fire damage from the 1983 fires. Actual route choice behavior is used to estimate a random utility model (RUM) that includes forest fire damage as one of the choice attributes. Total annual trips are estimated using a Poisson model of total annual trips as a function of the utility associated with a trip and demographic variables.

The estimated parameters of the two models are used to calculate the welfare damages from two of the 1983 fires. This information is used to suggest an analytical framework that may be useful in incorporating fire impacts on nonmarket economic outputs. Recognizing that the forest will regenerate, the current estimates of damages are used to calculate an intertemporal damage function. This damage function allows the estimation of the recovery path for the recreational values and the present value of the damage associated with fire.

Theoretical Background

This analysis requires the development of two relationships. The first is a random utility model of canoeing choices. The random utility model, however, allows the estimation of the welfare impacts of environmental quality changes on a trip basis. The aggregate changes in economic welfare across a season requires a trip generation function. We utilize the results of Yen and Adamowicz

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(1994) and Terza and Wilson (1990) to develop our Poisson generation function. The development of the random utility model is presented next with the Poisson trip generation function development following.

Random Utility Models

The discrete choice TCM provides a useful approach for addressing the valuation of forest fire damage by canoeists and has several attractive features. First, the discrete choice TCM concentrates on explaining site choice as a function of site attributes. Second, the model is developed from economic utility theory, and, therefore, defensible economic benefit estimates can be derived using conventional methods. Finally, the multinomial logit form of the model, which is used here, explicitly incorporates substitution among sites by examining all of the choices available to a canoeist simultaneously.

Discrete choice TCMs use random utility theory (McFadden 1974) to explicitly model choice among a set of substitute alternatives for each trip. In this application each canoeing trip occasion is assumed independent of the others. The site choice is modeled as a function of the characteristics of each alternative site. Recreationist i will receive utility, U , from visiting a site j equal to $U_{ij} = U(X_{ij})$, where X_{ij} is a vector of characteristics of site j . Utility is assumed to contain two components. The first part is known or observable to the investigator and the second part is not. Thus $U_{ij} = V_{ij} + \epsilon_{ij}$ where $V_{ij} = f(X_{ij})$ is the deterministic or observable component and ϵ_{ij} the unobservable component. ϵ can be interpreted as a random error term resulting from mis-specification of V_{ij} generated by unobserved characteristics of the individuals or recreation sites. Estimation proceeds by pooling individuals, choosing a particular functional form for the observable part of utility $V(\cdot)$ and choosing a distribution for ϵ .

This general model can be applied to a recreational canoeist by considering that the recreationist faces a choice of one site from a set of C possible sites. The probability (π) that site j will be visited is equal to the probability that the utility gained from visiting j is greater than or equal to the utilities of choosing any other site. Thus for individual i :

$$\pi(j) = \text{Prob}[V_{ij} + \epsilon_{ij} \geq V_{ik} + \epsilon_{ik}; \forall k \in C] \quad (1)$$

The multinomial logit model estimates these probabilities if the ϵ 's are assumed to be independently distributed Type-I Extreme Value variates (Weibull). McFadden (1974) shows that this assumption allows the site choice probabilities to take the form:

$$\pi_i(j) = \frac{\exp(V_{ij})}{\sum_{k \in C} \exp(V_{ik})} \quad (2)$$

Once the variables in the observed or deterministic component of the utility function $V(\cdot)$ are specified and a functional form selected, one can estimate parameters of the utility function using maximum likelihood techniques. The

functional form commonly chosen for $V(\cdot)$ is linear (e.g., Bockstael et al. 1990, Coyne and Adamowicz 1992):

$$V_{ij} = \beta_1 + \beta_2 X_{ij2} + \beta_3 X_{ij3} + \dots + \beta_n X_{ijn} + \mu(Y_i - P_{ij}) \quad (3)$$

where X_{ijn} represents n site attribute variables, Y_i is income, P_{ij} is the travel cost of visiting the site, and the β s and μ are parameters to be estimated. Income generally drops out of the formulation because it does not vary by site; in essence site probabilities are assumed to be homogeneous of degree zero in income.

Variables that can be incorporated into the utility function include travel costs and site characteristics. Since they do not vary across sites, the characteristics of the recreationists do not directly enter the estimation procedure. The qualities of sites do vary across the choices and so they enter the model directly. These allow substitution to be explicitly incorporated in the model.

The underlying utility theory allows computation of per trip welfare estimates. Hanemann (1984) showed that the expected utility on any given choice occasion is the sum of utility gained from each choice times its respective probability of being chosen. He used expected utility to estimate the compensating variation associated with a change in prices or quality attributes associated with choices. Thus, measuring a change in welfare associated with decreasing some quality attribute in the indirect utility function involves estimating the amount individuals must be compensated to remain at the same utility level as before the decrease. The following formula, modified from Hanemann (1984), shows this calculation:

$$CV = -\frac{1}{\mu} \left[\ln \left(\sum_{j \in C} \exp(V_{j0}) \right) - \ln \left(\sum_{j \in C} \exp(V_{j1}) \right) \right] \quad (4)$$

where CV is the compensating variation, μ is the marginal utility of income,¹ V_{j0} is the utility level in the initial state or quality level, and V_{j1} is the utility level following a change in quality.

Count Participation Model

As Morey (1994) has recently suggested, it is difficult to interpret the per trip welfare estimates without a model that generates seasonal trips unless one assumes that each trip is independent. Yen and Adamowicz (1994) have proposed a model that nests the per trip RUM with a Poisson model of seasonal trips. The Poisson seasonal trip model is generated by summing a series of binomial choice occasions during the season. As Hellerstein and Mendelsohn (1993) have shown, the sum of these choice occasions converges to the Poisson distribution. In this model the number of trips taken by an individual is a function of the utility associated with a trip (the inclusive value) and demographic variables.

¹ In our application, income is approximated by the price and is assumed constant across all individuals. This is approximately true because each choice is a small fraction of income. If one or more of the choices were a large fraction of income then one would need to use income—cost.

Seasonal trips are modeled as

$$q = \exp \left(\alpha_0 + \alpha_1 \text{inclusive value} + \sum_{i=1}^n \alpha_i Z_i \right) \quad (5)$$

where the q is the number of trips in a season, α_0 is the intercept term, α_1 is the parameter on the inclusive value associated with trip (calculated from the parameters of the multinomial logit model discussed above) and α_i denote the parameters associated with n demographic variables (Z_i). Note that since we have information on only visitors we use a truncated Poisson model.² By estimating and linking both models we can examine the value of site qualities and how changes in qualities affect total visitation to the park.

The welfare calculations provided by Morey (1994) show how to link the two models together. In short, the change in characteristics at a site will lead to a rearrangement of site choices in the multinomial logit portion of the model and possibly to a change in the total number of trips which is modeled in the Poisson portion of the model. Total changes in welfare are found by multiplying the change in the number of trips by the change in welfare per trip. The importance of each of these is an empirical issue.

Data

This model is applied to canoeing trips taken to Nopiming Provincial Park, a large forested area situated 125 miles northwest of Winnipeg, Manitoba. The park has no entry fee and largely caters to camping and backcountry canoeing, although a forest company is allowed limited harvesting of trees to provide wood for a pulp mill located nearby in Pine Falls. The presence of Nopiming Park provides recreationists with a transition area between forested wilderness to the north inaccessible by road (Atikaki Wilderness Park) and more highly developed recreation (cottages and resorts) to the south (Whiteshell Provincial Park).

Permit Data

While canoeing occurs throughout the park, park management provides five designated entry points for backcountry routes. Current research suggests that the vast majority of trips are from these points (Watson et al. 1994). Before canoeing from these points, canoeists are required to register with the Manitoba Natural Resources Parks system. The registrations from the spring and summer of 1991 and 1992

were obtained and provide the revealed preference data set necessary for the analysis of route choice.

Information from a total of 529 visitor parties (274 in 1991 and 255 in 1992) were collected. These parties included a total of 980 individuals in 1991 and 1004 in 1992. Only registrations with complete trip information were used in this analysis, which reduced the sample to 498 visitor parties. The information collected from each registration included the names of all members in the canoeing party and the address of the group leader. This information allowed us to identify 425 individuals who took one or more trips to the park during these 2 years. It also required registrants to outline their route along with their point of return, the date and time of return. Of the 498 visits, 480 were by 416 different individuals to 5 routes defined in maps provided to visitors by the provincial government and an additional route that was undesignated. Of the 416 individuals, 365 took a single trip, 42 took 2 trips, 7 took 3 trips, and 2 took 5 trips to the park.

As with Hellerstein (1991, 1993) the group leader's address was used to calculate the distance from home to the entry point of the route. While about half of the trips involved individuals from Winnipeg and its surrounding communities, the remainder were from other Manitoba communities (e.g., Brandon), and more distant places such as Minnesota, North Dakota, Alberta, and Saskatchewan. To obtain some demographic information we utilized postal or zip code level socioeconomic data from the U.S. and Canadian censuses.

Distances were measured by tracing routes on topographical maps and/or city and highway maps from the Manitoba Department of Transportation with a planimeter. We also used a computer software package to assess distances traveled by U.S. visitors. The Canadian Automobile Association reports a transit cost of \$0.22/km as the average cost to traveling 1 km using an average vehicle. This figure was used to translate distance into out-of-pocket travel costs.

Travel costs also include the opportunity cost of travel time (Shaw 1992). We utilize the procedure recommended by the U.S. Water Resource Council and value travel time at one-third of the individual's wage rate. The hourly wage was determined by estimating income from 1991 census data relating to the postal code reported on the registration, and dividing this by the number of hours worked per year. The travel cost variable is calculated using the following equation:

$$\begin{aligned} \text{travel cost} &= 0.22 * \text{distance} \\ &+ 1/50 * 1/3 * (\text{income} / 2080) * \text{distance} \end{aligned}$$

where travel cost is the sum of transit cost and opportunity cost of time. An average individual's average speed while traveling to the routes was assumed to be 50 kph.

Focus Groups

Following entry of the registration data into a computer data base, two focus groups were held. One group was a random sample of park visitors while a second was a sample of Manitoba Parks field staff. These groups were led in a discussion of canoe route attributes (Watson et al. 1994). Although focus groups provide qualitative information, they

² Note that, at least in principle, the registration system is a census of all canoeists. We construct our total visits by matching registration names and addresses. If a respondent registers three times, the count of total annual trips is constructed by matching up the three registrations. Notice that if every canoeist registered as requested we would recover exactly the same people as surveying every person in Canada and the United States and throwing out the people with zero trips. Frequent visitors show up precisely the correct number of times in the data. This is distinctly different from *sampling* on site. If the data had been drawn by site-based *sampling*, the data would suffer from endogenous stratification. If one samples on site, one is more likely to interview people who visit more often, and it may be important to apply an endogenous stratification corrected model. These count models are explained and applied in Shaw (1988) and more recently by Englin and Shonkwiler (1995).

are nevertheless very valuable in determining such things as likely model specification and expected signs.

A series of pictures of various forest stand types and associated disturbances were ranked by the participants. Pictures of a stand burned in 1983 and of a cutblock were ranked lowest while mature jackpine stands with rock outcrops was ranked highest. The results suggested that fires within the last 10 yr were important attributes. This result led to an emphasis on fire impacts in the study of important canoe route attributes.

Attribute Data

Using fire history maps and actual visits to the routes, it was noted that parts of the forested shorelines along some of the routes were burned by two severe fires that occurred in 1983. The Maskwa Lake Fire caused damage to two routes, and the Long Lake Fires burned forests to varying degrees along five of the routes. A third fire in 1989 burned some small portions of the Manigotogan route. All of these fires consumed large areas of shoreline along the routes and fire damage was thus readily visible to canoeists. Fire damage in forests of the Canadian Shield is distinguishable from other disturbances many years after its occurrence. Actual visits to the routes by the authors revealed visible charred remains of trees, obviously burned deadfall, and regrowth of fire adapted conifers about 1–2 m in height. There are no other disturbances in the park that have the same effect on the landscape from a visual point of view, are as large, and look like historical fires.³

To quantify the extent of these burned areas, provincial forest inventory, historical fire distributions, and other geographical data were loaded into a geographical information system. Canoe routes were located and digitized and a 200 m buffer was formed on both shores and including islands for the entire route length. Since the registrations suggested that most individuals paddled the entire length of routes, the following was calculated for each route: total area of the buffer, the total buffer area affected by the 1983 fires and other fires that occurred between 1983 and 1992, and the total buffer area of old growth—timber that has reached rotation age or older (overmature) using the provincial forest inventory. This information was used to derive variables describing the amounts of burned areas or old growth an individual canoeist would “consume” while traveling the route. Three formulations for these forest variables were attempted: the actual area (km²) of the route buffer they comprised, their

proportion of the total route buffer, and the linear distance (km) they comprised along the total length of a route.

Other potential attributes associated with choices of the six routes for canoeing were collected during actual visits by the researchers to the park, by examining a map of the park provided to park visitors, and by examining topographical maps. Dummy variables (0,1) representing the presence of a store or fuel facility, launching site, or campground at the entry points, were derived. Five of the six routes had at least some of these features. The presence of large lakes on the route (at four of six routes), the number of portages (ranging from zero to nine) and their lengths were also tried in the analysis.

Results and Discussion

Travel Cost Model

Travel cost model results are shown in Table 1. Other specifications were attempted, but correlation among attributes or statistical insignificance resulted in the number of portages, distance between the launching point and the closest overnight campground, the presence of large lakes on the route, and length of the longest portage being rejected from the analysis. The variable describing amounts of old growth forest along the routes was collinear with burns, but when entered separately, was significant and positive. It seems that in this forested part of the Canadian Shield, recreation choice can be examined using burns or mature forests, but not both simultaneously since they appear to describe the same thing in this dataset.

The final set of variables tried in the analysis included alternative specific constants (ASCs) which are commonly used in discrete choice analysis to account for differences in utility that are not accounted for by the included attributes. Ideally, five ASCs should be included (theoretically $n - 1$, where n is the number of alternatives), but given correlation among ASCs and other explanatory variables this is unlikely. Therefore, subsets of ASCs were tried that corresponded to unusual characteristics of the various routes. Misspecification can result from the exclusion of ASCs since they act as constants within each utility function.

The travel cost variable is negative, as expected, and highly significant. The presence of a launch positively influenced choice. The burn variable is negative and significant, suggesting that canoeists prefer routes which are not burnt.⁴ A number of sets of ASCs were tried in the analysis, and one set containing two, the Seagrim Lake route and the Manigotogan River route, performed the best. The Seagrim ASC is negative, likely due to the existence of a large portage from the entry point to the start of the waterway. The Manigotogan River ASC is positive and significant. This is likely due to the route's historical significance.

Poisson Participation Model

The Poisson model is estimated using each individual in the sample as an observation. Following Yen and Adamowicz

³ A referee suggested that fires would be indistinguishable from other disturbances and that the regenerating forest would mask the effects of fire. The only type of disturbance that might be close to a fire is cutblocks. However, the presence of forestry activity is virtually impossible to observe from the canoe routes. Field work involving considerable time on the routes suggests that few canoeists, if any, leave the waterway to hike or walk in the forests. This would be the only way, in the authors' opinion, that individuals could locate cutblocks from a canoe route. In any case, cutblocks are different than burns once an individual is standing in them. They are also much smaller in area and have much less impact on the landscape from a visual standpoint: cutblocks made by the forest company are very small, look considerably different than 10 yr old burns, and at present do not occur very often near canoe routes. The company is also required to leave a 60 m uncut buffer along waterways in the Park, but usually leaves a considerably larger buffer of uncut trees.

⁴ Both specifications of the burn variable, area of buffer and proportion of route, performed the same. The former is presented in this paper due to its greater relevance for analysis of welfare changes.

Table 1. Multinomial logit and Poisson data analyses results for Nopiming Park.

Variable	Coefficients*	
	Multinomial logit model	Poisson trip frequency model
Constant		-1.88654** (1.051)
Inclusive value		-0.15400 (0.1396)
Income		0.039694*** (0.0245)
Travel cost	-0.02324**** (0.00629)	
Launch	4.77614**** (1.2000)	
1983 burn	-0.150704**** (0.0153)	
Seagrim Lake route	-0.286124**** (0.1297)	
Manigotogan River route	1.88734**** (0.5555)	
ρ^2	0.2754	
Log-likelihood	-623.47	-190.60

* Standard errors are reported in parentheses.
 ** Significant at the 10% level.
 *** Significant at the 11% level.
 **** Significant at the 1% level.

(1994) we include a constant, the inclusive value calculated from the multinomial logit RUM,⁵ and income. We find that the parameter on the income variable is positive and significant at the 11% level. The parameter associated with the inclusive value is insignificant at conventional levels. This suggests that each trip is independent. Changing qualities (and thereby changing the inclusive value) will not change the total number of trips taken by an individual to the park.

The implication of this for the welfare estimates is that, since the number of trips is insensitive to changing site qualities, we can simply use current trips to predict welfare effects. Of course, this result only holds for the range of qualities found in the existing sample. It may be that the number of trips taken in a year will change if the qualities are changed substantially enough. This finding is consistent with Brown and Mendelsohn (1984,) who also found that total trips were insensitive to changing site qualities.

Estimation of Fire Impacts

While the models can be used to describe a wide variety of potential forest and management changes, we focus exclusively on the impacts of existing and potential forest fires. Two types of welfare impacts are examined. The first involves returning the affected canoe routes back to their "pristine" state following the 1983 fires. This was performed by reducing the burns to zero along the appropriate routes and assessing the welfare impact using Equation (4). The effects of the Maskwa fire involved damage to two routes. Total welfare changes for an individual are calculated in both cases by multiplying the change in welfare per trip by the number of trips that person took. Table 2 reports the full set of results. Reducing the damage acreage along these routes to zero generates a 1993 aggregate welfare benefit valued at \$6,626.43. Similarly, when damages caused by the Long Lake fire, which burned

portions of three routes, are reduced to zero, the welfare benefit is valued at \$7,529.63.

Two other welfare simulations are of interest. One calculation examines the welfare loss that would occur if the most popular route, the Tulabi Lake route, were to be entirely burned as a result of a large forest fire. In this scenario the aggregate annual losses are estimated to be \$13,725.79.⁶ Fires along this route would be worse than the damage associated with all existing fire damage combined. The second scenario examined is the case where the remainder of the Manigotogan route is damaged by additional fires. In this case the aggregate losses are smaller at \$390.87.

Our results raise some interesting questions about the temporal welfare effects of forest fires. The effects of forest fires *fade* over time through forest renewal. While it is possible that the time path of the welfare effects of recovery from a fire could be a nonlinear function, we have only enough information to speculate on a linear analysis. We examine the Long Lake fire as an example. The linear

Table 2. Welfare impacts of four forest fire scenarios for Nopiming Park.

Scenario	1993 aggregate welfare change (\$)
Return burned areas to natural forest	
1983 Long Lake Fire	7,529.63
1983 Maskwa Lake Fire	6,626.43
New fires burn all of an additional route	
Tulabi route	-13,725.79
Manigotogan route	-390.88

⁵ We utilize a two-step procedure. First we estimate the multinomial logit and then use the calculated inclusive value in the Poisson estimation. This procedure is less efficient than estimating the two models simultaneously.

⁶ Strictly speaking, the damages simulated using the parameters in Table 3 are for a period about 10 yr after the fire since that is the age of the Maskwa Lake and Long Lake fires.

analysis proceeds from two observations. One is that the impact we observe today,⁷ losses of \$15.46 (\$7,529/487 trips) per trip, results from a fire that occurred about 10 yr ago. Second, the forest will return to climax conditions, assuming no further fires and thus no negative impacts on canoeing, in about 100 yr (Bella 1968). If we assume that the value associated with climax forest is zero, we can use these two points to solve for the linear function that relates welfare losses and time. This function is:

$$\text{Damages} = -\$17.18 + \$0.1718 * (\text{years since burn})$$

The total per trip damages from the fire is found by discounting the damages in each year back to the present. The present value of the damage function can be expressed as:

$$\text{Present value of damages} = \int_0^{100} [-17.18 + 0.1718 * x] e^{-r * x} dx$$

By choosing different discount rates, r , one can calculate the present value of the Long Lake forest fire. The present value of total per trip losses is about \$577 at a 4% discount rate. Aggregate total losses are found by summing over all trip takers.

Summary and Conclusions

An important forest management issue is the effect of forest fires, not only on timber values, but also on nontimber values. This analysis provides a framework for examining some values at risk in a forest in Manitoba, specifically the impact of fires on the recreation values associated with backcountry canoeing. We found that while the presence of a developed canoe launching site increases recreation value, the presence of historical fires along a route were a disamenity to backcountry recreationists. The losses associated with the 1983 Long Lake fire were estimated to be more than \$15.46 per trip almost 10 yr after they occurred. The quantification of fire damages also allows us to construct a crude damage function. By utilizing our knowledge of forest regeneration we are able to calculate a linear damage function that results from forest fires.

An important aspect of this analysis and the resulting welfare estimates is that the participation decision is unrelated to qualities. While this has been found by other authors in the past (e.g., Brown and Mendelsohn 1984), it suggests

that one must use care when extrapolating the results. The independence between total visits and site qualities probably does not hold regardless of the scale of quality change.

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⁷ Calculated using Equation (4).