Journal of Agricultural and Resource Economics 33(1):19–33

Fire and Recreation Values in Fire-Prone Forests: Exploring an Intertemporal Amenity Function Using Pooled RP-SP Data

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An important consideration in managing fire-prone forests is the intertemporal impacts of forest fires. This analysis examines these impacts in a forest recreation setting by fitting a combined stated and revealed data set to explicitly model the effects of forest regrowth following a fire on recreation economic values. The results are particularly useful as they provide clear measures of the time path of recovery of forest amenity values following a fire.

Key words: forest fire, recreation valuation, revealed preference, stated preference, travel cost model

Introduction

The levels of participation in various types of recreation in forested areas in North America are substantial. For example, Williamson, Hoscheit, and Luttrell (2002) estimate Canadians spent 18.5 million days participating in recreational activities on forested lands during 1996. This represented approximately 80% of all outdoor recreation user days in Canada in that year. Recreation clearly has significant social and economic value that should be reflected in management decisions. The importance of recreation in forests has resulted in the selection of measures of recreation participation as relevant indicators of sustainable forest management reporting in Canada (Canadian Council of Forest Ministers, 2000).

Despite recreation being an important use of most forests in North America, incorporation of the economic values of recreation in the management of these forests is challenging because it is typically a nonmarketed activity. Numerous studies have examined the economic value of forest recreation using a variety of techniques (e.g., Walsh, Johnson, and McKean, 1988). Few of these studies have focused on the changes in recreation economic values and use as forest environments are modified through anthropogenic or natural disturbances. Increasing societal awareness of forest health issues and rising costs of pest control and fire fighting have led forest managers to

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Review coordinated by Douglas M. Larson.

consider cost-benefit analyses of resource allocation decisions. Incorporating the economic values of nonmarketed forest resources into these decisions is becoming an important consideration for managers (González-Cabán, 1993).

The literature on fire and recreation interactions has been slow to develop. Initial studies using the contingent valuation method (Vaux, Gardner, and Mills, 1984; Flowers et al., 1985) found intense fire events are likely to have negative impacts on recreation, but the duration of these effects is more difficult to establish. The negative effects of fires, at least in the few years following a significant fire event, were also supported in revealed preference approaches by Englin et al. (1996) and Boxall, Watson, and Englin (1996) using actual recreation choice behavior in a Canadian case study. These latter researchers postulated the existence of an intertemporal damage function which, when tied to forest age, could be increasing linearly over time up to some maximum represented by an old growth condition. This function would be reset to a negative value following a fire.

However, the early revealed preference research cited above was limited in that the researchers were only able to observe responses of recreationists to forest ages of 10 and 64 years following a fire. In response to this limitation, a number of studies have recently been conducted which take advantage of combined stated and revealed methods as proposed by Englin and Cameron (1996). Such a combined approach is well suited for developing an understanding of intertemporal damage issues as it allows cost-effective sampling of recreation responses to fire-affected forests of different ages while maintaining a strong link to actual observed recreation behavior. In essence, the procedure allows researchers to gather information in experimentally contrived situations which include stand ages beyond those currently experienced by recreationists.

Englin, Loomis, and González-Cabán (2001) and Loomis, González-Cabán, and Englin (2001) were the first to use this procedure in a pooled travel cost contingent behavior count framework. Further research by Hesseln, Loomis, and González-Cabán (2004) and Hesseln et al. (2003) validated the approach. The research reported by these authors utilized trip frequency as the response by recreationists to changes in forest condition as a result of fires. Loomis, González-Cabán, and Englin (2001) found differential effects on hiking and mountain biking visitation levels as a result of different ages of fires and burn intensities in U.S. National Forests in Idaho, Wyoming, and Colorado. Using the same data, Englin, Loomis, and González-Cabán (2001) found that annual trip frequencies and recreation values following fires were nonlinear. Hesseln, Loomis, and González-Cabán (2004) and Hesseln et al. (2003) reported that in New Mexico and Montana, respectively, recreation demand fell in response to prescribed burns and wildfires.

In this study we examine the impact of forest fires on recreation demand in a fire-adapted ecosystem in the boreal Canadian Shield region. In contrast to the combined revealed preference-stated preference (RP-SP) count framework, we use changes in recreation site choice as the behavioral response to changes in the forest resulting from fires because the recreation activity is wilderness canoeing, with most participants taking a single trip in any given year. The random utility model (RUM) framework of Adamowicz, Louviere, and Williams (1994) and Adamowicz et al. (1997) for examining recreation site choice is especially appealing in settings where most individuals make a single trip. A further appeal of the RUM is its ability to incorporate substitution between sites in response to spatial differences in temporal fire occurrences.

Methods

In examining the effects of fire on recreation, researchers are limited by the existing range of forests in one area of different ages following fires. Information collected from recreationists on-site must be augmented if researchers require information about the effect of the forest ages outside the range of those actually experienced by recreationists at the site under examination. One way to augment the on-site revealed preference data is to add stated preference data designed to assess changes in intended behavior resulting from changes in environmental conditions. An analysis where revealed and stated preference information is pooled for the same set of individuals represents a potential solution.

As discussed above, previous research on fire and recreation utilized pooled travel cost and contingent behavior information, focusing on trip frequencies or counts. An alternate analytical procedure is the recreation site choice framework in which recreationists switch their sites and adjust their expenditures in response to fires and changes in forest age. To use this approach in pooling revealed and stated site choice information, a random utility model can be employed.

Consider a recreationist with an indirect utility function (U) consisting of the sum of two components: an observed component V_i, and a random component ε_i. This recreationist chooses a recreation site i from a set of $\mathbf{C}$ sites. The probability (π) that site i will be visited is equal to the probability that the utility gained from visiting site i is greater than or equal to the utilities of choosing any other site in $\mathbf{C}$. The probability of selecting site i can be written as: $\pi(i) = \Pr\{v_i + \varepsilon_i \geq v_k + \varepsilon_k, \forall k \in \mathbf{C}\}$.

As shown by McFadden (1973), the choice probabilities take the following form if the random components are assumed to be independently distributed with a type-I extreme value distribution:

$$\pi(i) = \frac{\exp(\mu V_i)}{\sum_{k \in \mathbf{C}} \exp(\mu V_k)}, \tag{1}$$

where μ is a scale parameter. For recreation applications, this model is typically estimated with the observable component, V_i, expressed as a linear function of m site attributes (X_i) and the costs of visiting the site (e.g., Englin et al., 1996; Boxall, Watson, and Englin, 1996). Thus, when site attributes are substituted into the deterministic portion of utility and a linear functional form is selected to identify their contribution to utility, V_i becomes:

$$V_i = \sum_{n=1}^{m} \beta_n X_i^n + \gamma(Y - P_i), \tag{2}$$

where β_n represents the weights or parameters on the m attributes, Y is income, P_i is the cost of choosing alternative i, and γ represents the marginal utility of income. The parameter γ and the parameter vector $\boldsymbol{\beta}$ can be estimated using maximum-likelihood techniques, and since the scale parameter is not estimable in a single set of choice data, convention involves setting $\mu = 1$. In this study we assume the alternative sites differ by costs, site attributes such as stand types, and ages of forests.

Earlier work (see Adamowicz, Louviere, and Williams, 1994; Adamowicz et al., 1997) dealt with the modeling issues surrounding the use of a pooled RP and SP data set. In this setting a single model is estimated that restricts the parameters of the indirect utility function to be the same regardless of the source of the data. This is essentially Cameron's (1992) insight that the underlying data generation process should be the same—i.e., all data should be generated by the same utility function. One measure of the internal consistency of restricting the parameters of the utility function to be the same regardless of the source of the data is to test whether the scale parameters are equal, which is accomplished by normalizing the scale parameter for either the RP or SP data to one and estimating the scale parameter for the other data set (Swait and Louviere, 1993). This approach exploits the fact that in any single data set, μ is not identifiable, but if more than one data set is available, the ratio(s) of the scale parameters can be identified (e.g., μ_{rp}/μ_{sp}).

The procedure for handling pooled data assumes statistical independence of the multiple data sets. In this case the data sets would be the revealed and stated preferences from the same individual. Ben-Akiva and Morikawa (1990) and Morikawa (1994) provided evidence that SP responses can be influenced by previous actual or revealed choices. Cameron (1992) and Huang, Haab, and Whitehead (1997) demonstrated that revealed and stated responses from the same individuals could be correlated. Thus, an empirical issue in pooling RP and SP data is accounting for potential dependence between individuals' RP and SP responses.

In the empirical setting described here, we use the procedures proposed by Boxall, Englin, and Adamowicz (2003) to incorporate dependence between individuals' RP and SP responses. These insights follow Morikawa (1994) who found that "previous choice dummy variables" in the indirect utility function could absorb unobserved factors relating to the preference of some alternatives over others. Depending on the econometric structure employed in incorporating these previous choice dummies, correlation among the choices can also be captured (Herriges and Phaneuf, 2002). For example, panel estimation methods explicitly account for the correlation over time in unobserved utility arising when there are repeated choices by a given agent. Herriges and Phaneuf outline other econometric procedures to examine serial correlation among multiple sources of choice data. These procedures were adopted by Boxall, Englin, and Adamowicz in conjunction with previous choice parameters.

To make the procedures discussed above more concrete, consider an experiment where RP choice data are pooled with a single set of SP choice data. In the equations below, the SP conditional indirect utility function for site i is adjusted by including a dummy variable for the RP choice alternative:

$$(3)\qquad U_i^{RP} = \sum_1^m \beta_m X_{jm} + \gamma(Y_n - p_i) + \varepsilon_i^{RP},$$

$$U_i^{SP} = \sum_1^m \beta_m X_{jm} + \gamma(Y_n - p_i) + \delta Z_i^{RP} + \varepsilon_i^{SP},$$

where Z_i^{RP} represents the RP choice and equals 1 if site i is chosen and 0 otherwise. In this case the SP response may be dependent on the actual RP behavior. A test of whether δ is significantly different from zero would reveal the effect of the previous RP choice on the stated preference choice.

Construction of the pooled RP-SP data set in this paper is more complex. This analysis includes one set of actual choices (the RP data) and a set of SP data consisting of three choices (SP1, SP2, and SP3) arising from a contingent behavior exercise involving a sequence of three related questions. Having four sets of choice occasions for each individual raises the question of whether the RP choices (dummies) should enter the indirect utility functions for each of the SP data sets, or if SP1 choices (dummies) are sufficient to capture state dependence in SP2, and SP2 choices in those of SP3. As Boxall, Englin, and Adamowicz (2003) suggest, this issue is a question of the "lag length" one employs in the dependence structure.

An additional concern raised by Boxall, Englin, and Adamowicz is whether the state dependence effects should be alternative specific or equal across all alternatives. In their empirical study which considered the same region and sample of recreationists, however, alternative specific state dependence did not significantly improve estimation of parameters or their interpretation.

To illustrate the state dependent choice framework used in the present study, the following series of equations illustrates the lag length employed and the effect of state dependence:

$$\text{(4)} \qquad \begin{aligned} U_i^{RP} &= \sum_1^m \beta_m X_{jm} + \gamma(Y_n - p_i) + \varepsilon_i^{RP}, \\ U_i^{SP1} &= \sum_1^m \beta_m X_{jm} + \gamma(Y_n - p_i) + \delta^{PC1} Z_i^{PC1} + \varepsilon_i^{SP1}, \\ U_i^{SP2} &= \sum_1^m \beta_m X_{jm} + \gamma(Y_n - p_i) + \delta^{PC2} Z_i^{PC2} + \varepsilon_i^{SP2}, \\ U_i^{SP3} &= \sum_1^m \beta_m X_{jm} + \gamma(Y_n - p_i) + \delta^{PC3} Z_i^{PC3} + \varepsilon_i^{SP3}. \end{aligned}$$

Given a pooled RP-SP model where β and γ are constrained to be equal across the four sets of data, various state dependent frameworks can be examined. The first is "generic" state dependence where δ is constrained across alternatives but not necessarily constrained across the previous choices Z_i^{PC}.[1] This model assumes the utility function for site i using the pooled data would be:

$$\text{(5)} \qquad U_i = \sum_1^m \beta_m X_{jm} + \gamma(Y_n - p_i) + \delta(Z_i^{PC1} + Z_i^{PC2} + Z_i^{PC3}) + \varepsilon_i .$$

The second framework is state dependence where δ remains constrained across alternatives but is allowed to vary across the previous choices in each set of choice data. This model assumes the utility function for site i would be:

$$\text{(6)} \qquad U_i = \sum_1^m \beta_m X_{jm} + \gamma(Y_n - p_i) + \delta^{PC1} Z_i^{PC1} + \delta^{PC2} Z_i^{PC2} + \delta^{PC3} Z_i^{PC3} + \varepsilon_i .$$

We estimate the δ coefficients on state dependence as random normally distributed over the sample which permits their interpretation as reflecting heterogeneity in the

[1] In this empirical analysis, alternative specific state dependence was not included because the findings of Boxall, Englin, and Adamowicz (2003) did not uncover any advantages in including alternative specific state dependence. Furthermore, the smaller sample size employed here and the number of previous choice parameters to be estimated made estimation of alternative specific effects problematic.

sample arising from different levels of experience with forests, fires, and canoeing, or as implicitly different "initial conditions" arising from different histories of choosing recreation sites.[2]

Various specifications of the state dependent process could be estimated. Thus, in the constrained and unconstrained state dependent frameworks, the actual route choice appears as the previous choice for each of the SP sets of data. This specification can be represented by {RP, RP, RP}. Other specifications one could examine employ previous choices represented by appropriate sequences of the RP and SP choices in both constrained and unconstrained frameworks. For example, two possible specifications could be: {RP, SP1, SP2} and {RP, RP, SP2}. In our experience, some of these models had difficulty converging or did not provide superior econometric performance to the reported frameworks. Hence the results are not reported here.

To consider correlation across our series of choice occasions, mixed logit panel estimation was used. Panel estimation explicitly accounts for the correlation over time in unobserved utility arising when there are repeated choices by a given agent. Further consideration of correlation can involve the use of econometric approaches outlined by Herriges and Phaneuf (2002). Such procedures were employed by Boxall, Englin, and Adamowicz (2003) in the presence of a similar, but simpler state dependent analytical framework. Their findings uncovered no serial correlation remaining in the presence of the previous choice dummy variables. These results suggest that the addition of previous choice variables in combination with the use of the panel estimators could capture any correlation present.[3]

The Data

The study analyzes wilderness recreation in Nopiming Provincial Park, a 1,440 km^2 area located about 145 km east of Winnipeg, Manitoba, in the Precambrian or Canadian Shield (see Boxall, Watson, and Englin , 1996). The park contains networks of lakes and several river systems consisting of small rapids and waterfalls that are attractive to backcountry recreationists interested in canoeing and kayaking.

Most of the land in the park is forested and its location in the Canadian Shield yields many rock outcrops covered with jack pine in varying size classes. Bogs and other low-lying wet areas contain mostly black spruce. Due to a recent history of widespread fires, jack pine has gained prevalence and is probably the most abundant tree species in the park, followed by black spruce, trembling aspen, and white spruce. The recent fire history, coupled with limited logging, has resulted in large areas of regeneration. Rarely does a stand cover more than a 20-hectare area.

Previous research on wilderness recreation in this park and the surrounding region focused on economic assessments of the importance of fire, forest ecosystems, and other features (Boxall, Watson, and Englin , 1996; Englin et al., 1996). Part of these efforts involved the development of a detailed inventory of features along canoe routes, verified through intensive fieldwork. The inventory incorporated various spatial databases

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[2] This initial conditions problem is pervasive in all panel data structures and, as Boxall, Englin, and Adamowicz (2003) claim, the random parameter approach can be considered as one way to address this issue.

[3] Indeed, we employed the procedures suggested by Herriges and Phaneuf (2002) and found that correlation among the errors was statistically insignificant in the presence of the previous choice parameters.

provided by Manitoba Natural Resources including the provincial forest inventory, fire history maps, and other information for the period 1989–1993 for those townships included in the park. Forests in the park had been subjected to particularly extensive fire events in 1983, but were also affected to a lesser extent by earlier fires. The township and base data were loaded into a geographical information system (GIS) where the shorelines along canoe routes were buffered into corridors of 200m (including islands). Along each route the ages and types of forests in these corridors were quantified and used as attributes explaining route choices in 1993 and 1994. Since recreationists using these routes rarely traveled far from shore, we were able to show in earlier research that the forest features in these shoreline corridors were significant explanators of route choices (Boxall, Watson, and Englin, 1996). Our previous findings prompted further examination of forest age on route choice using stated preference methods reported here.

In 1994, the existing voluntary registration system was enhanced to identify the frequency of visitation to the backcountry canoe routes in the park. These enhancements included the addition of 11 registration stations to the six existing ones, as well as systematic observations of canoeists arriving at the stations, to develop estimates of participation in the registration system. Watson et al. (1994) provide details of the registration survey system and the substantial efforts employed to enhance and understand levels of compliance with this registration system. Moreover, there are considerable incentives for recreationists to use the registration system. Specifically, the registry will give park managers knowledge of when and where registered participants are located in the event problems or emergencies arise during their trip.

In early 1995, the registrants were sent a mail survey. The survey sample was created using the names of the leaders of the recreation parties who registered for a backcountry canoe trip in Nopiming Park in 1993 or 1994. The original sample of 661 registrants was reduced to 587 by eliminating incomplete addresses, and multiple trips by the same individual. There were, however, very few recreationists who took more than one trip in a year—the mean number of trips was 1.19 trips per registrant. The final sample included individuals from five Canadian provinces and three American states.

The survey included an SP experiment[4] involving the presentation of three stated preference scenarios in which forest conditions were altered at two routes in the park. Respondents were asked if they would adjust their 1993 or 1994 actual route choices in response to the hypothetical conditions described in each scenario. The design exploited our knowledge of the respondents' trip history. Respondents were offered the chance to change their trip to another route in response to a change in the forests along the corridors of the route they actually visited. Since the original trip was known, in each scenario a respondent was presented with forest changes at the site we knew he or she had visited during the study period. Thus, in each of the three scenarios, respondents could opt to change their chosen route in response to the hypothetical changes in forest conditions to another route, or to continue to visit the route they actually visited and "enjoy" the altered conditions at that route. Figure 1 gives a generic example of the stated preference questions used in the experiment.

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[4] The survey actually included two SP experiments. The first, described in detail by Boxall, Englin, and Adamowicz (2003), involved responses to the hypothetical presence of aboriginal pictographs.

Currently much of the forest along the ____________ route looks like photograph ___ on the center page (page 7). Suppose _____km of this water route (about ___% of its length) had been burned by a forest fire in 19___, about ___ year(s) before your trip. The forest would now look like photograph ___ on the next page (page 6). Knowing this, would you still have visited this route?

YES ❑

NO ❑

If you chose NO, what would you have done instead? (check one only)

❑ Visited another route in Nopiming.

Which one?

❑ Rabbit River ❑ Seagrim Lake ❑ Beresford Garner Lakes

❑ Manigotagan River ❑ Other (please specify)______________

❑ Visited a route in another park.

Figure 1. A generic example of one stated preference question used in the examination of forest age changes due to fire along two canoe routes in Nopiming Provincial Park, Manitoba

The changes in forest condition involved adjustments in the ages and quantities of jack pine stands within shoreline corridors along the canoe routes. Respondents were first reminded about the current quantity and ages of pine forests along the route they actually chose. Table 1 provides the actual quantities of two forest ages along the eight canoe routes comprising the choice set in the study. This description keyed on the extent of the historic 1983 fires in the routes examined in the study and was supported by presenting four photographs of forest stands of ages 1, 10, 30, and 65 years following fires. Following the reminder presentation, the experiment proceeded by changing the fire history along the route. The changes involved adjusting the percentage length (and hence corridors) of the route that would have been affected by the change. The photographs were used to further describe these changes.

To capture a range of changes in the quantities of forest ages and at different routes in the choice set, five versions of the survey instrument were used. Two of the versions focused on changes in forests at the most popular canoe route, Tulabi, and the other three on changes in the second most popular route, the Rabbit River. In some scenarios quantities of new forest ages of 1- and 30-year burns along the routes were introduced. In others, 10- and 65-year burned areas were increased or reduced.

Table 2 reports how the scenarios were constructed for the Tulabi and Rabbit River routes. Note that these forest age changes were communicated in terms of percentage of route length.[5] To illustrate the design, consider version 1 which is associated with changes at the Tulabi route only. The actual burned jack pine areas along the corridors of that route during the study period were 1% 10-year burns and 29% 65-year burns (table 1). None of the route corridors had areas comprising 1-year and 30-year burns.

[5] This approach was suggested to us by experienced canoeists in informal discussions in the planning phases of the study.

Table 1. A Summary of the Existing Distributions of Forest Ages in Eight Canoe Route Buffers in Nopiming Provincial Park, Manitoba

		Existing Forest Ages (% length)	
Canoe Route	Length (km)	10 Years	65 Years
Tulabi Lake	46	0.71	29.53
Shoe Lake	4	0.00	21.37
Rabbit River	32	60.00	18.62
Seagrim Lake	14	37.54	21.90
Gem Lake	34	67.41	0.00
Beresford Lake	34	28.83	0.36
Manigotagan River A	26	0.00	10.92
Manigotagan River B	61	0.00	2.29

Table 2. A Summary of the Changes to the Two Canoe Routes Presented to Manitoba Recreational Canoeists in the Stated Preference Contingent Behavior Questions

	Hypothetical Forest Ages (% length) Used in the Various Versions (V1, V2, ...)[a]			
Canoe Route	1 Year	10 Years	30 Years	65 Years
Tulabi Lake:				
RP–Actual	0	1	0	29
SP Scenario 1	11, 35[a]	1, 1	0, 0	19, 0
SP Scenario 2	0, 0	12, 35	0, 0	19, 0
SP Scenario 3	0, 0	1, 1	11, 35	19, 0
Rabbit River:				
RP–Actual	0	60	0	19
SP Scenario 1	0, 0, 0[b]	0, 6, 0	0, 0, 0	69, 62, 68
SP Scenario 2	0, 0, 0	0, 0, 0	50, 6, 50	19, 62, 19
SP Scenario 3	50, 6, 50	0, 0, 0	0, 0, 0	19, 62, 19

[a] The first number refers to the % length in version 1, the second refers to version 2.
[b] The first number refers to the % length in version 3, the second refers to version 4, and the third refers to version 5.

In the first SP scenario (see table 2), the forest ages in the corridor were implicitly adjusted to be 11% 1-year, 1% 10-year, 0% 30-year, and 19% 65-year jack pine stands—which can be referred to as [11, 1, 0, 19]. Thus, in the choice model, the characteristics of the Tulabi route for the first SP choice were adjusted to include the areas of forest stands reflected by these changed route lengths. The second scenario involved changes to the age structure of one represented by [0, 12, 0, 19] and the third scenario [0, 1, 11, 19]. The corresponding forest age structures for the three scenarios in version 2 of the questionnaire were [35, 1, 0, 0], [0, 35, 0, 0], and [0, 1, 35, 0] (table 2). A similar design was used for the Rabbit River route except changes to the forest age structure of that route were represented in three versions.[6]

[6] We note that because the order of the questions was not varied in the survey design, we cannot test for order effects.

The survey included a total of three mailings. First, a questionnaire with cover letter was sent to the 587 individuals in early March 1995, followed by a reminder postcard two weeks later. A second questionnaire with cover letter was sent to only nonrespondents after five weeks. These procedures resulted in the return of 431 completed questionnaires which, adjusting for undeliverables (e.g., people who moved, etc.), represented a response rate of 81%. Within each relevant sample segment, the versions of the questionnaire were randomly assigned.

The final data set used for this analysis consisted of respondents who provided information on all three SP questions, as well as those who did not decide to switch trips out of Nopiming Park to other parks that support wilderness canoeing. This trimming of the sample was conducted to focus the analysis on a single park only, as age structures of the forests along routes in other parks were unknown. The data included actual site choices by the respondents for 1993 or 1994 (RP data) and their stated choices from the questionnaire (SP data). In this information, the choice set was limited to the eight major routes in the park (table 1). Any respondent whose actual trips were not to any of these eight routes were also excluded from the analysis as their site choices would not have been affected in the SP scenarios. This process resulted in a final sample consisting of 287 respondents with complete trip and questionnaire data.

Boxall, Watson, and Englin (1996) identified 14 route attributes that explained the choice of 20 canoe routes in the same park, including travel costs,[7] amounts of the 1983 fires, the amounts of various forest ecosystems, indicators of the level of physical effort required to complete the route, and some alternative specific constants. These variables were initially examined as explanators of site choice, but only travel costs and two others could be identified in this study, which is based on the most popular eight of the 20 routes. The reduced number of routes suggests that only a subset of the full set of the independent variables used previously may be significant explanators of site choice in the reduced choice set. This finding is consistent with the explanatory variables employed by Boxall, Englin, and Adamowicz (2003) for the same eight routes, and by Englin et al. (1996) for six of the eight routes. Thus, the final set of independent variables included travel costs, the areas of 10-year burns, the areas of white spruce stands in the corridors, and an alternative specific constant (dummy variable) identifying the Manigotagan River, a challenging white water canoe route. This river is a provincially recognized river and in 2004 was designated as a separate provincial park. These variables, in addition to the areas of 1-, 30- and 65-year burns portrayed in the SP questions, formed the characteristics of the routes used to explain route choice.

Econometric Procedures

In the RP data and each of the three sets of SP data the eight routes form the choice set, and seven independent variables comprise the route characteristics; four of these were the forest age variables. To address the state dependence arising among these data sets, various vectors of specifications of the previous choices were used when pooling the data sets as described above. Three specifications were attempted. The first used a previous choice framework similar to the approach employed by Boxall, Englin, and Adamowicz

[7] In this calculation, out-of-pocket expenses were valued at Can$0.25/km and the opportunity cost of time was estimated as one-quarter of the respondents' average wage rate (Can$52,476.68/2,040 hrs.) and an assumed speed of 90 km/hr.

(2003). Specifically, the RP choices were designated as the previous choices for the first SP question (SP1), the SP1 choices as previous choices in the SP2 question, and the SP2 choices as previous choices in the SP3 question. As noted above, this can be written as {RP, SP1, SP2}. Models using this framework were estimated with both constrained and unconstrained random previous choice parameters as shown in equations (5) and (6). The second model framework used the RP choices as previous choices throughout the SP data components (i.e., {RP, RP, RP}) and both constrained and unconstrained specifications were employed.

The econometric analysis involved estimating conditional logit models and panel mixed logit models in which the state dependence parameters were specified as random, normally distributed variables. An initial test of the consistency of the RP and SP data prior to pooling was conducted and indicated the common parameters in each set of data were not significantly different ($\chi^2 = 0.122$, 4 df, $p > 0.05$). Parameters for the panel mixed logit models were estimated using the simulated maximum-likelihood program in LIMDEP with 150 Halton draws.

Results and Discussion

Table 3 provides parameter estimates for two pooled RP-SP choice models—one without previous choices and the other with the {RP, RP, RP} structure with unconstrained previous choice parameters. Because the {RP, SP1, SP2} model had difficulty converging, it is not reported here. The {RP, RP, RP} model with the constrained previous choice parameters converged, but the value of the log-likelihood function at convergence was larger for the unconstrained model reported in table 3, as was the ρ^2. A likelihood-ratio test revealed the previous choice parameters should be unconstrained ($\chi^2 = 94.0$, 4 df, $p < 0.05$). Based on these findings, the unconstrained model specified the state dependence process that best fits the data.

The first choice model in table 3 reports estimates in which no parameters were random and none of the previous choices were included in the estimation. Travel costs were negative and significant as expected. The amount of white spruce stands in the route corridor buffers and the alternative specific constant for the white water canoe route (Manigotagan) were positive but not significant at the 5% level. All quantities of the forest age/burn parameters were significant. The 1-year burn parameter was positive, the 10-year burn negative, and the 30- and 65-year burns were positive. These parameter estimates suggest a damage function that increases sharply immediately following a fire (implying a positive amenity effect), declines to below 0 (indicating damages), then increases to a level higher than that for the 1-year level, and finally declines by more than half at 65 years.

This shape, graphed in figure 2, is contrary to prior expectations based upon the function developed by Englin, Boxall, and Hauer (2000) for the same geographic area. In particular, the 1-year positive effect and the portion of the function from 30–65 years following a fire seem at odds with comments made by participants at route entry points and members of focus groups with the Manitoba Recreational Canoeing Association whose input we sought in the initial planning phases of our wilderness research efforts.

For the other model summarized in table 3, the travel cost parameter remains negative and significant and is of the same magnitude as the pooled model without state

Table 3. Recreation Site Choice Models Estimated Using Combined Revealed and Stated Preference Site Choice Information With and Without the Influence of Previous Choices (state dependence)

	Without State Dependence (no previous choices)		With State Dependence (with previous choices)	
Variable	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Travel Costs	-0.0210**	0.0027	-0.0164**	0.0067
1-Year Burn (km^2)	0.2073**	0.0307	-0.5642**	0.1321
10-Year Burn (km^2)	-0.0279**	0.0118	0.0066	0.0227
30-Year Burn (km^2)	0.2856**	0.0309	0.3363**	0.0718
65-Year Burn (km^2)	0.1229**	0.0150	0.3846**	0.0432
White Spruce (km^2)	0.5255*	0.1667	2.9042**	0.4921
Manigotagan ASC [a]	0.0371	0.1226	0.4897*	0.2454
δ^{RP1}			8.5610**	1.4498
$SD\ \delta^{RP1}$			3.8748**	1.2004
δ^{RP2}			6.5130**	1.9411
$SD\ \delta^{RP2}$			1.0582	2.5202
δ^{RP3}			4.0554*	0.6733
$SD\ \delta^{RP3}$			2.6090**	0.8523
Log Likelihood	-2,016.23		-980.37	
ρ^2			0.589	

Note: Single and double asterisks denote $p < 0.10$ and $p < 0.05$, respectively.
[a] ASC refers to an alternative specific constant for this canoe route.

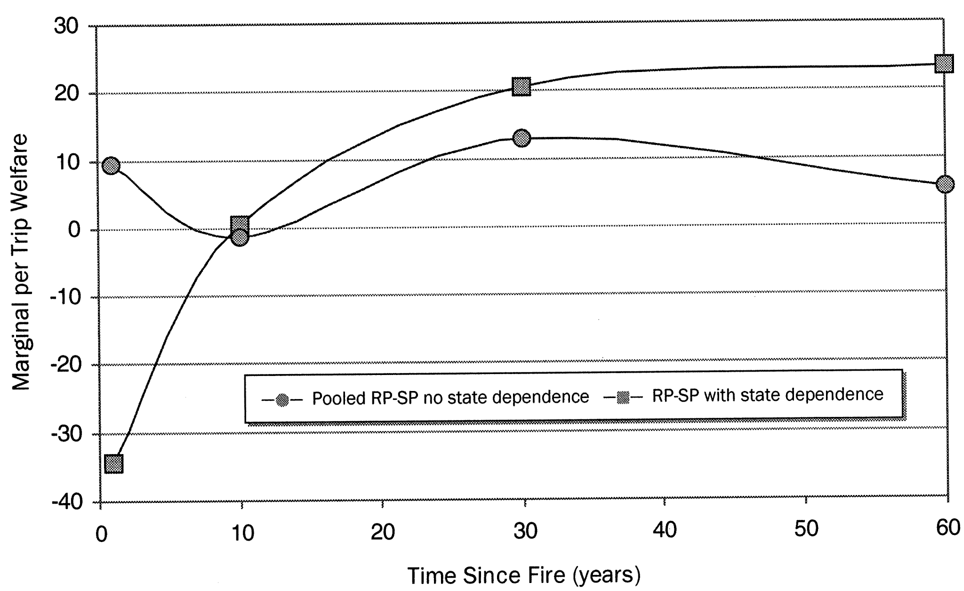

Figure 2. Two intertemporal damage functions for recreational canoeing in the Canadian Shield boreal forest with and without state dependence

dependence. The white spruce parameter is large, positive, and statistically significant. The positive effect of this attribute on route choice is supported by the strictly revealed preference study of Boxall, Watson, and Englin (1996) for the same individuals to the same park. The differences between this model and the previous one, however, lie in the forest age/burn parameters. In this case, the 1-year burn parameter is negative and significant, indicating respondents would not choose routes with areas of forests aged at one year, and pointing to the finding that freshly burned areas provide disamenities. This effect lasts until around the 10-year mark where the parameter estimates for the 10-year burn are not significantly different than 0. At about 30 years of age, the forests are again providing amenities and positive amenities continue to be provided up to the 65-year point.

The shapes of these two damage functions are shown in figure 2 where the utility for each forest age in the SP experiment was converted to a marginal per trip welfare measure using the approach of Hanemann (1983) and the welfare functions were interpolated between these forest ages. Based upon intuition gathered through interviews with canoeists and our own visits to the study area, we suggest that the model with state dependence provides a more accurate portrayal of the true damage function than the simple pooled RP-SP data. In particular, the positive value of the 1-year forest in the model with no state dependence seemed incorrect given what experienced canoeists told us. These regenerating forests are not very accommodating for camping; they are muddy when wet and attract biting insects.[8] Furthermore, the declining per trip welfare in the older stands also seemed at odds with our knowledge of this recreation activity in the region.

The state dependence specification in the preferred model used the revealed route choice (RP choices) in each of the three SP data sets. The effect of the actual revealed choice on the responses to the stated preference question was allowed to vary across the three sets of SP data. The estimated individual parameters are approximately 8.6, 6.5, and 4.1 for the first, second, and third SP questions, respectively. This formulation of state dependence would appear to fit the SP question design, in which each respondent was required to consider each question independently of the previous one. In addition, the question was clearly anchored on each respondent's actual trip. Thus, we feel this supports the independent effect of the actual route choice on each SP choice.

It is also noteworthy that the effect of the RP choice declined through the sequence of SP questions (δ^{RP1}, δ^{RP2}, and δ^{RP3} in table 3). However, the heterogeneity of the effect of state dependence in the sample of respondents was largest in the first and last SP questions and was statistically insignificant in the middle question in the sequence. This result suggests the effect of state dependence was reduced across the three-question sequence, but nonetheless is still apparent. It is more difficult to interpret the heterogeneity of these effects. These findings do reveal that respondents were less influenced by their actual route choices as the SP questions were answered. Further research is warranted to fully estimate and understand the significance of this observation.

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[8] While we acknowledge the possible existence of positive amenities of fire due to the novelty of viewing recent burns (such as in Yellowstone National Park following the fires of 1988), forest fires in the Canadian Shield are frequent events. Consequently, residents and visitors are likely to be much more familiar with these events and would tend to have little interest in viewing recent burns, especially during long wilderness trips.

Summary and Conclusions

Developing an understanding of the intertemporal fire damage function has been the focus of several previous studies. The motivation for conducting these analyses is to support ecological modeling work and to forecast post-fire on levels of use in forested recreation areas. Early research in the Canadian Shield boreal forest (Englin et al., 1996) was limited by its dependence on observed variation in forest age following forest fires. The present analysis allows a more precise intertemporal time path to be developed because it is based upon stated preference data that were designed to elicit a more accurate picture of the true time path of values when combined with the revealed preference data. For recreational canoeing in the Canadian Shield boreal forest, the damages associated with a fire occur in the early years following a fire. After about 35 years of regrowth, however, the amenity value provided by these forests appears to return to the previous older growth condition.

An important consideration in the development of these estimates was the treatment of state dependence. As shown here, and in the 2003 study conducted by Boxall, Englin, and Adamowicz, several kinds of state dependence could be possible in pooled RP-SP data. Interestingly, modeling the effect of the actual routes visited in each of the three stated preference data sets in our study provided the best fit. This finding should not be surprising because the experimental design of the SP questions requested respondents to consider their actual route choice in each question. Yet, there was significant dispersion in the size of the state dependent effect across the respondents, making the use of random coefficient econometric approaches important. The form of state dependence uncovered in this study is somewhat different from the results reported by Boxall, Englin, and Adamowicz, suggesting that modeling state dependence is not a routine modeling choice but should be related to the design of the stated preference exercise employed.

Our investigation was exploratory in that it involved a relatively small sample of recreationists and also examined a rather specialized activity. Future studies could assess other recreational activities in the same forest ecosystem and utilize general population surveys to fully identify the behavioral responses to fire damages. For example, linking site choice with trip frequency dynamics in response to fires would provide an improved understanding of related economic welfare impacts. In addition, there is no reason to suspect that damage functions in the boreal forest are similar to those in other forest ecosystems. Thus, expanding research beyond boreal forest ecosystems would also be a worthy endeavor.

[*Received June 2006; final revision received January 2008.*]

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