An Empirical Examination of Non-market Values of Wilderness Recreation and Their Role in the Industrial Use of a Canadian Forest

Peter Boxall, Canadian Forest Service, Alberta, Canada;
Jeffrey Englin, University of Nevada-Reno, USA; *David Watson,* Canadian Forest Service, Alberta, Canada

This paper analyses the influence of forest characteristics, levels of development, and other features on recreation site choice in Nopiming Provincial Park in Manitoba, Canada. It then uses this information to estimate an intertemporal amenity function. A Hartman rotation model is formulated which includes fire risk. The amenity function is integrated with timber growth in this model and the effects of fire and amenities are assessed in the economic optimal rotation. The results suggest that harvest should be delayed despite fire risk since older forests provide significant non-timber values in this park.

1 Introduction

A concern in the industrial use of most of Canada's forests involves integrating timber and non-timber values. This is due to the fact that the majority of forested lands are publicly owned. In addition, for most parts of the nation, forest fires are a natural phenomenon. Fire effects on timber values are understood, but fire impacts on non-timber values have yet to be examined.

This study examined these issues in an empirical setting in Nopiming Provincial Park in Manitoba, Canada. Nopiming was selected because its forest characteristics make it representative of a number of wilderness parks in the western Canadian Shield and limited logging is permitted within its boundaries generating significant environmental issues. Forests in the park have been subjected to extensive fires, most recently in 1983, which could affect both recreational and industrial activity. Furthermore, park management involved an on-going registration system for wilderness visitors with no entrance fees or access restrictions. Thus, non-market values would be important in assessing non-timber values in the park and travel cost methods could be applied to the registration data.

The paper first describes random utility travel cost models which were used to examine non-market values associated with forest characteristics including historical fires. It then develops an amenity function using non-market values associated with forest stands of two ages. Next optimal rotation models are discussed and a Hartman model with fire risks is presented. Finally, timber growth and amenity functions are used in this model to simulate rotation ages under various fire risks.

2 *The random utility model*

2.1 Theory

Assume a recreationist, *i*, receives utility from visiting a wilderness site, *j*. This utility U_j is composed of two parts, a deterministic portion V_j and a random error term e_j such that:

$$U_j = V_j + e_j. \tag{1}$$

Each recreation trip is assumed to be independent of others, and site choice is modelled as a function of the characteristics of each alternative site from a set of *C* possible sites in a park or wilderness area. The probability (*p*) 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*:

$$\pi_i(j) = \text{Prob}[V_{ij} + e_{ij} \geq V_{ik} + e_{ik};\ \forall k \epsilon C]. \tag{2}$$

McFadden (1974) showed that the conditional logit model estimates these probabilities if the e's are assumed to be independently distributed Type-I Extreme Value variates (Weibull). The choice probabilities thus take the conditional logit form:

$$\pi_i(j) = \frac{\exp(V_{ij})}{\sum_{k \epsilon C} \exp(V_{ik})} \quad . \tag{3}$$

Using this model to examine recreation choice behaviour requires: 1) a set of recreation sites (*C*) among which individuals are choosing to visit; 2) the specification of variables in the observed or deterministic component of the utility function *V*; and 3) the selection of a functional form for *V*. Actual or other quantitative assessments of the attributes associated with the different sites comprises the values of the inputs in *V*. This coupled with a set of data which provides the actual choices or revealed preferences of the recreationists for the sites in *C*, allows estimation of the conditional logit model using maximum likelihood techniques (Ben-Akiva and Lerman, 1985).

The application of this model to recreation in Nopiming Park is fully described by Boxall *et al.* (1996a) and only a summary appears here.

2.2 Recreation data

Visits to the park by the authors, inspections of maps and aerial photographs, and discussions with park managers and recreationists provided a list of water routes used for wilderness recreation in the park. This information was used to expand the existing voluntary registration system in the park to cover additional wilderness entry points and an on-site survey was provided to visitors at each point. The survey, shown in Watson *et al.* (1994), asked for the name and address of the group leader, the number of people in the group, and other information about the current and past trips to the site. Registrants were asked to trace their expected route and camping locations on a map on the back of the survey. A registrant's postal or zipcode and residence location was used to calculate travel distances between their residence and backcountry entry points in the park. Estimates of household income were determined by linking postal or zipcodes with the most recent census data. This estimate will be crude, but is commonly used in the absence of individual income data.

The distance and income measures were used in the following formula to calculate travel costs for each registrant:

$$\text{travel cost} = \$0.22 * \text{distance} + [1/50 * 1/3 * (\text{income}/2040) * \text{distance}]. \quad (4)$$

This identifies the two components of travel cost: i) the out-of-pocket expenses for the vehicle, estimated at $0.22/km (Alberta Motor Association, pers. comm.); and ii) the opportunity costs of travel time, estimated at one third of the wage rate (Cesario, 1976). Note that an average speed (including stops) of 50 kph was assumed, and that the hourly wage rate was calculated by dividing income by an estimate of the number of hours worked (2040) during the year.

2.3 Attribute data

Most of the park is forested, and due to a recent history of widespread fires, jack pine (*Pinus banksiana*) is the most abundant tree species, followed by black spruce (*Picea mariana*), trembling aspen (*Populus tremuloides*), and white spruce (*Picea glauca*). Other tree species are also present but are not as common. The recent fire history, coupled with limited logging, has resulted in large areas of regeneration.

A set of forest ecosystem variables was chosen based on the results of a focus group (Watson *et al.*, 1994; Boxall *et al.*, 1996a) and on-site visits by the authors. These included jack pine, black spruce, white spruce and aspen. A compilation of the forest types along water routes was constructed based on their contribution to the area of 200 m buffers adjacent to each watercourse. Route inventories compiled by the authors, inspection of maps, forest inventories and GIS analysis were used to develop area-based measures of forest and fire history attributes. Stands were classified using the predominant tree species present (comprising > 40% of the trees). Their ages were identified as either 'mature', which included trees of 10 m height or greater, and 'young' which included smaller trees and disturbed areas. Based on fire history data, the mature jack pine stands were found to be 64 years of age or older. Other characteristics such as recreation development features (e.g. cottages, portages) were assessed through onsite inspections.

2.4 Estimation

The forest variables and other features were examined for statistical significance in explaining the probability of choosing one of 20 routes in the park. Each recreationist was assumed to travel along the entire water route so the characteristics found in the buffers along the entire length of the route were used in the analysis. Alternative specific constants (ASCs) were used to account for some differences in utilities not explained by quality attributes. The functional form chosen for V was linear and the discrete choice program in LIMDEP was used to estimate the parameters.

2.5 Modelling results

Table 1 contains the results of one RUM model using 388 trips to 20 different water routes in the park during 1993. Three additional models are reported in Boxall *et al.* (1996a). Travel costs were a significant negative influence on site choice as expected (Fletcher *et al.*, 1990). The area (in km^2) of mature jack pine and white spruce stands are a positive influence, while areas of mature black spruce and aspen stands are a negative influence on site choice. The presence of the 10-year (1983) burned areas,[1] cottage developments, large numbers of portages, and long portages negatively effected site choice as suggested by the negative signs on their coefficients. ASCs for two routes, the Manigotagan River and Seagrim Lake route, were estimable and are positive.

Table 1. Estimates of parameters from a multinomial logit model explaining choice of water recreation route in Nopiming Park, Manitoba in 1993.[a]

Variables	*Parameters*	*(t ratio)*
Travel cost	-0.0600***	(-4.914)
Burns of 10 years or less	-0.1016***	(-3.538)
Mature jack pine	0.6798***	(9.837)
Mature black spruce	-0.9988***	(-6.847)
White spruce of any age	6.2236***	(5.929)
Aspen of any age	3.1102***	(-5.603)
Cottages	-1.3374***	(-8.449)
Longest portage	-0.0018***	(-5.126)
Number of portages	-0.0774***	(-8.007)
ASC - Manigotagan	3.8477***	(6.493)
ASC - Seagrim Lake	0.6614***	(3.256)
Log likelihood at convergence	-861.23	
ρ^2 [b]	0.259	

[a] - t statistics in parentheses

[b] - a statistic analogous to R^2 and is calculated as $[1-L(\beta)/L(0)]$

*** - significant at the 1% level or beyond

As an aside, the direction of the effects of these factors in influencing site choices made some sense in explaining actual choices in this park. For example, camp sites are probably better in jack pine and white spruce areas. There may be fewer insects and the ground is likely to be drier than in black spruce or aspen ecosystems. The density of trees is also more conducive to camping in mature jack pine due to its dispersed nature on rock outcrops and flat areas. Scenic preferences may also influence route choice – a focus group of recreationists chose jack pine stands over black spruce, hardwoods and fires.

1 Boxall *et al.* (1996a) present other models where the 10-year burn variable was replaced with the areas of immature or regenerating stands of jack pine and black spruce. The coefficients for these variables were negative and highly significant in the case of jack pine. This lends confidence to the results since regrowth should conceivably influence choice in the same direction as burnt areas since they are measuring similar landscape features.

2.6 An intertemporal amenity function

Since burned areas from the 1983 fire provided a disamenity to recreationists 10 years after the fire, and mature jack pine stands provided a positive amenity, a function can be constructed to describe the recreation benefits of jack pine stands over time. This function is based on two points: the first an estimate of the 1983 fire damages 10 years after the fire, and the second an estimate of the benefits provided by mature forest stands 64 years following fire. Marginal values of one hectare of these two ages of stands were estimated by dividing their parameter values in Table 1 by the travel cost parameter. Converting these values from a km^2 to hectare basis yielded values of \$0.0169 and \$0.1133/ha/trip respectively. Note that the 10-year-old fire (10-year-old forest in 1993) provided negative values while the mature forest (64 years or more after fire) provided positive values. Following Englin (1990) these two points were used to estimate a two-piece linear function for an individual recreationist:

$$\text{Value} = -0.041 + 0.002(t), \text{ where } t < 65 \text{ years},$$
$$\text{Value} = 0.089, \text{ where } t \geq 65 \text{ years}.$$

This function, shown in Figure 3.4, suggests fire damages are worth -\$0.041/ha when the fire occurs and increase to \$0.00/ha at about 17 years following fire. Stands continue to increase in value until 64 when they reach a constant positive value for ages greater than 64 years.

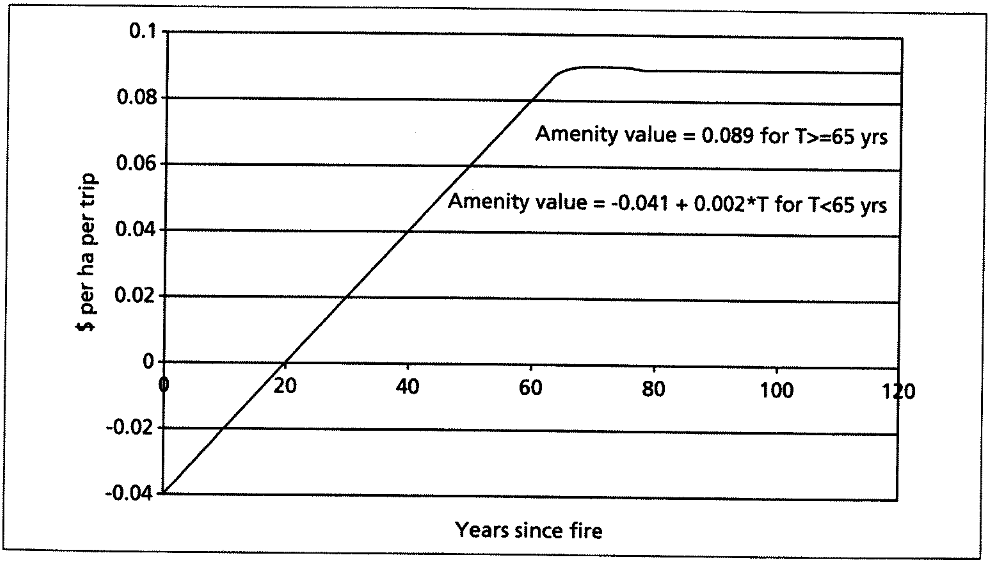

Figure 3.4 Fire damage and the effect of time.

3 The optimal rotation model

Economic aspects of timber harvesting are frequently examined through optimal rotation models. The Faustmann model is the original development of this problem, but only considers timber values in a deterministic framework. Hartman (1976) extended the basic Faustmann model to include amenities affected by forest harvests. The Hartman objective function is:

$$\frac{(V(T)-c_1)\,e^{-rT} + \int_0^T F(x)e^{-rx}dx}{1-e^{-rT}}, \tag{5}$$

where $V(T)$ is the value of timber at time T, c_1 is the harvesting cost, r is the discount rate, $F(x)$ is the flow of amenities and $\int F(x)\ e^{-rx}\ dx$ is the discounted flow of amenities. Differentiating this with respect to T and rearranging yields the classic Hartman harvesting rule which equates the rate of change of the value of the stand $(V'(T)+F(T))$ to the interest rate.

An additional extension to the Faustmann model was the inclusion of fire risks formulated by Reed (1984). Reed showed that fire risks serve to shorten timber-only rotation periods since delaying harvest increases the risk of losing value due to fire. In the Nopiming case, however, multiple use of forest stands is a concern. Thus, integrating fire risk into the Hartman model is appropriate. The Hartman objective function with fire risk is:

$$\frac{(r+\lambda)((V(t)-c_1)\,e^{-(r+\lambda)T} + e^{-\lambda T}\int_0^T F(x)e^{-rx}dx}{r(1-e^{-(\lambda+r)T})} + \frac{\lambda}{r}(-c_2+\int_0^T F(x)e^{-rx}dx)\ , \tag{6}$$

where l is the Poisson parameter describing the average rate of fires and c_2 is the cost of replanting following fire or harvest. The derivation of this function involves considerable calculus (see Englin and Boxall, 1996) which is not reported here for brevity.

The harvesting decision in Nopiming was modelled with (6) using available data. The amenity function described above was used for $F(x)$ and the timber growth function was:

$$1\text{n}(m^3/ha) = 6.1192 = 66.6471\,(age)^{-1} \tag{7}$$

which was derived by fitting a logistic growth function to Bella's (1968) growth and yield data for jack pine. The simulation involved substituting these functions into (6), setting the harvesting and post-fire replanting costs to zero, and calculating the value of the objective function for a series of rotation ages ranging from zero to 150 years under a set of fire risks. The rotation age that maximised the value of the objective function is the optimal rotation age.

Table 2. Jack pine rotation ages in years under different fire risks and recreational use intensities*.

Fire risk (%)	*No recreationists*	*19 recreationists*	*300 recreationists*
0.0	35	36	42
0.5	34	34	40
1.0	33	33	39
1.5	31	32	38
2.0	30	31	37

* Note that these rotation calculations do not include costs.

Table 2 shows the results. The first column shows the likelihood that a hectare in this area of Manitoba will burn in a year. This risk is assumed to be independent of the age of the forest. The second column shows the optimal rotation age for a forest with no amenity values. These range from 35 years with no fire risk (the standard Faustmann result) to 30 years if the risk is 2% per year. Two recreational use scenarios were simulated: i) 19 users per year which was the average utilisation of a site in 1993; and ii) 300 users per year which is about the maximum use of the park by recreationists during 1991–1994. The general result is that the amenity benefits of the standing forest provide an incentive to delay harvest. The delay ranges from zero to seven years depending on recreational use and fire risk. Note that in this geographical area estimates of the actual fire risk are about 0.015, or about 1 year in 60 (Martell, pers. comm.).

4 Conclusions

Since multiple use and integrated management of forests requires optimising public benefits, managing forests at risk from fire compels understanding the magnitudes of the economic impacts of fire. Some of these impacts involve changes in the non-market economic values that accrue as a result of fires. Wilderness recreation in the region of the Canadian Shield examined is important and provides a highly valued non-market outputs (Boxall *et al.*, 1996b). To fully quantify the non-market impacts of forest fires one needs the values of forests in both burned and unburned states. This analysis has focused on the development of a framework to assess the aesthetic impacts of forest fires on recreation in these states.

For Nopiming Provincial Park this analysis suggests that optimising both timber and non-timber values in the presence of fire requires managers to delay harvests beyond timber-only rotation periods. While this result is not surprising to researchers familiar with economic optimal rotation theory and models, this analysis is one of a very few that examines these issues in an empirical setting. Furthermore, this analysis helps multiple use managers justify the full consideration of a range of economic variables in managing the park.

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