Assessing the Impacts of Forest Management on Aboriginal Hunters: Evidence from Stated and Revealed Preference Data[1]

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Abstract: Assessing the impacts of forest harvesting activities on Aboriginal People and incorporating these considerations into forest management plans is one of the challenges facing Canadian forest managers. In this study we model hunting behavior using stated and revealed preference data on subsistence use of wildlife resources. We use this framework to assess the impacts of forest management changes on Aboriginal People in northwestern Saskatchewan. Innovative approaches to data collection are employed to address challenges in obtaining data in these contexts. The econometric analysis combines the stated and revealed preference information to account for limitations in the revealed preference data. Monetary measures of welfare are examined, but we also assess resource compensation and zoning as mechanisms for addressing the impact of forest harvesting on subsistence wildlife use. The results also demonstrate the use of GIS information in linking forest management and Aboriginal resource use.

Introduction

Most forest management activity in Canada takes place on public land. Forest managers operating on public lands are required to take into account non-timber values in addition to timber values when making management plans. One of the major beneficiaries of non-timber values are Aboriginal People (Haener and Adamowicz, 2000). The majority of Canada's Aboriginal People live in the forest and forest resources are culturally as well as materially important for them (Tobias and Kay 1993; Usher 1976; Beckley and Hirsch 1997). Aboriginal People also account for a substantial percentage of northern Canada's population and their population growth rates are significantly higher than the rest of the Canadian population (DIAND, 2001). Policy makers have begun to recognize that the values of Aboriginal People should be incorporated into management planning and forestry activity and are increasingly requiring forest managers to consult with Aboriginal People before embarking on management plans.

It is not clear, however, how the values of Aboriginal People can be incorporated into forest management planning. Conceptually, these values could be incorporated by adjusting the optimal timber rotation and harvesting plan for non-timber values (Bowes and Krutilla, 1985; Mendelsohn, 1996). This would involve measuring the values associated with non-timber goods at different forest ages and modifying rotation ages and harvesting plans to account for these values (e.g. Englin, 1990). In practice difficulties arise when collecting general harvest information given there are many non-timber goods to consider, and the spatial nature of their values must be accounted for to be useful from a forest management perspective. A further difficulty is that information about the use of non-timber goods is privately held by Aboriginal People and this information on wildlife harvesting, for example, will not be freely released because of its value to hunters and its sensitive nature. Information may also be withheld because of the cultural importance of certain sites or activities. Aboriginal protests against forestry activity may also result in difficulties in gathering information on non-timber harvest activities. Given the cultural significance of these resources, and that different regulations apply to Aboriginal harvesters, information from recreational hunting licenses and related wildlife harvest statistics that are routinely gathered from non-aboriginal hunters are not relevant for most aboriginal hunters. These issues suggest that data gathering techniques used in typical studies of recreational hunting demand are not useful in an Aboriginal hunting context.

In addition to obtaining information on activity levels or use of non-timber products, incorporation into economic models typically requires assessment in monetary terms, which introduces further difficulties. First, monetary valuation may imply property rights that are rejected by the Aboriginal People. Property rights issues surrounding Aboriginal Peoples' access and rights to forest resources remain controversial. A contingent valuation approach that requests a willingness to pay for improved quality of non-timber goods would likely be rejected as it implies that the Aboriginal People do not have the rights to the resource. An approach that involved an offer of compensation would also likely be rejected, in part because of the usual difficulties with compensation based contingent valuation but also because of the lesser importance of monetary transactions for some segments of the Aboriginal population. In cases where monetary values have been required for compensation replacement cost methods have been used (e.g. Usher, 1976). Even though these methods have been criticized (Beckley and Hirsch, 1997; Brown and Burch, 1992; see also Haener et al. 2001b) they continue to be popular in applied work. In this paper we view the impact of forest management activity as broader than simply a reduced harvest of wild game. In fact, forestry activities may result in increased game populations in some cases, yet they may reduce the welfare of the hunters. Therefore, we choose to model actual behavior and focus on the behavioral changes and implied value changes arising from changes in the forest environment. A behavioral approach also allows us to examine non-monetary as well as monetary measures of compensation.

The challenges described above can be summarized as data collection challenges and valuation challenges. In this study we describe an integrated approach that attempts to address both issues. The study is carried out in a Forest Management Area (FMA) in Northern Saskatchewan. Mistik Management, a not-for-profit corporation, manages this area. Mistik's management's objectives are to manage the 3.3 million ha area to provide fibre for a pulp mill and a sawmill located near Meadow Lake Saskatchewan. The company is to do this without compromising the non-timber resources flowing from the forest region. A unique aspect of this situation is the fact that a single entity manages a large landscape with the objective to supply mills with different fibre requirements. Furthermore, the Meadow Lake Tribal Council[1] owns the NorSask sawmill to which Mistik Management supplies fiber. Thus, concerns regarding the flow

[1] This is an organization consisting of nine First Nations that is charged with providing services and programs to facilitate economic development for the communities in the region.

of non-timber resources to Aboriginal People are integral to Mistik's land management approach. The firm has also put considerable effort into developing co-management boards with Aboriginal communities in the region and providing mechanisms for Aboriginal People to benefit from the employment opportunities created in the region.

This paper begins with a description of a data collection effort that focused on building trust and developing the research program in cooperation with the communities. This unique data collection approach, we believe, is likely the only way to collect data of the type required for assessment of aboriginal non-timber values[2]. Three types of data were collected: (1) Information on "special sites" identified by members of the Aboriginal Community was collected. The community members expected the researchers to pass information on these sites on to the management agency so that action could be taken to avoid harvesting in or near these sites, though no cessation of forestry activity was promised by the researchers or Mistik. This information included identification of areas with high moose populations, cabins, salt licks and other attributes of the land. This "traditional ecological knowledge" of the hunters is an important component of our modeling strategy. (2) Information on actual hunting activities was collected from Aboriginal hunters. The collection of this revealed preference (RP) information is described below. (3) Stated preference (SP) information was collected to better identify preferences for attributes of wildlife harvesting sites. In addition to the data gathered from the Aboriginal People, data on forest characteristics were obtained from geographical information system (GIS) data provided by Mistik Management.

After describing the data collection process the paper continues with a description of the modeling process (combining RP and SP data) and the simulation of hunting behavior following forest-harvesting plans. The impacts of forest harvesting on hunting are examined using monetary welfare measures as well as a form of resource compensation. In addition, an alternative forest management strategy that involves concentrated forest harvesting (or zoning) is explored.

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[2] The data collected at the individual level are confidential. Even representations of predicted activities (maps, etc.) that are based on these individual data are considered confidential. In this paper results are presented in aggregate form or in cases where more disaggregate results are presented, all identifiers have been removed to prevent any possibility of revealing individual level information. The use of such information in forest management planning clearly requires a similar degree of protection of confidential information by the management agency. Without such agreements it is unlikely that private information of this type will be made available.

The results suggest that modeling actual behavior can be used as a method of capturing some of the value of non-timber resources accruing to Aboriginal People. These methods also provide significant insight into the impact of forest harvesting on non-timber activities. However, substantial investments in data collection are required in order to obtain data for such analysis. Furthermore, challenges in identifying the opportunity cost of time make the monetary valuation of non-timber resources difficult. Use of resource compensation methods, however, appears to be promising. The methods presented in this paper provide insights into the potential for resource compensation as a practical way to incorporate the value of Aboriginal People into forest management. The analysis of zoning, or concentrated forest harvesting versus dispersed harvesting, also suggests potential for this as an approach that incorporates Aboriginal values into forest management. The paper concludes with a discussion of some of the limitations of the study and challenges associated with incorporating Aboriginal values into forest management planning.

Data Collection

Study Area and Sample

The study area for this project is the Millar Western-NorSask Forest Management Agreement (FMA) area in northwestern Saskatchewan, which extends along the Alberta-Saskatchewan border, comprising 3.3 million ha of land (see Figure 1). The current population of the FMA area is about 25,000 spread over about 22 communities in and around the FMA area. This population includes people of Cree, Dene, Metis and European descent. Although NorSask utilizes the softwood and Millar Western utilizes the hardwood in the region, the landscape planning for the region as a whole is undertaken by Mistik Management Ltd. Mistik's mandate is "to provide the mills with a long term sustainable wood supply while taking into account the many resources and uses of the forest" (Mistik Management Information Booklet).

Data Collection Process

Initial contacts with the communities and the forest management agency identified that even though Aboriginal People are engaged in collection and use of many different non-timber forest products, large game harvesting (in particular moose; deer and caribou to a lesser extent) was considered the most important for this study. The community members themselves were interested in participating in a study of hunting as this activity is important culturally as food for hunters and other members of the community, and as an activity that could be significantly affected by forest management actions. Thus, the initial contacts with the communities to obtain permission to conduct research also helped to focus the research question on a topic of interest to the communities. An approach that engages the community in defining the research program is emerging as a requirement in conducting research with Aboriginal communities.

During the period October 1999 to September 2000, 124 interviews with Metis and First Nations hunters were conducted in 7 communities (Green Lake, Waterhen, Canoe Narrows, Jans Bay, Cole Bay, Beauval and Dillon) representing 5 co-management areas. Slightly more Metis (59%) hunters were interviewed than First Nations (41%) hunters. In addition, an attempt was made to capture hunters from both northern (37%) and southern (63%) communities, to facilitate investigating the influence of better access to larger commercial centers on harvesting behavior.

The process by which the data were collected differed from previous hunting research in the economic literature. Data were collected in informal in-person interviews. While the design of the survey was to be a straightforward question and answer session, the interview that evolved was more of a conversation allowing "story telling" and elicitation of information from a conversation. The interviews took approximately 40-120 minutes and averaged just over one hour. Further information on the sample and the interview process can be found in Dosman et al. (2002).

Trust was an important factor in the entire process. Community members were apprehensive about discussing hunting and trapping activities with a stranger, especially a non-Aboriginal person. In response, we employed one primary interviewer who became known in the communities and developed relationships with the local people. We also employed a community resident who socially and culturally had access to the hunters. This person helped to arrange interviews, attended them to ease the participants, and translated some unfamiliar concepts. The interviewer lived in the communities for approximately one year, which facilitated the development of trust between the interviewer and community members. The fact that the interviewer lived and participated in the community was a fundamental component of the research process.

Reciprocity also played a vital role in securing relationships with the respondents. Reciprocity for participation in the study was offered at several levels. First, the research group made a commitment to report back the findings to each of the communities. Each hunter was asked during the mapping exercise to identify special sites such as nesting areas, calving areas, burial sites, cabins or historical sites. A map of special sites was created for each community and presented to community leaders. Second, an incentive of a draw in each community for a gift certificate at a local hunting store was offered to all respondents. Individual respondents responded favourably to the incentive. Third, in interviews with First Nations elders an offering of tobacco was made at the beginning of the interview. This offering is a sign of respect and helps to formalize the relationship between the interviewer and the elder.

Revealed Preference Information

Hunting trip information for the past hunting season was collected in two complementary formats. The first was a traditional trip log, which recorded the location and frequency of each trip. It also included information on the approximate distance traveled, the modes of transportation, with whom the trip was taken, the duration of the trip, the season of the trip and the number of moose and other game harvested by the individual being interviewed and by the group.

The second format was a map of the NorSask FMA area on which the hunters drew their general hunting area and the location of the trips recorded in the trip log.[3] We defined the general hunting area as the entire area in which an individual hunter would consider going to hunt moose.

Both the map and the trip log were used simultaneously in collecting information. Some of the more traditional hunters would require significant interpretation of the map because they were not accustomed to seeing horizontal representations of the land base. Once this was accomplished, the use of a map as a visual tool worked to make the respondents feel more at ease with the process. Many informants preferred to talk in stories and they would point out the sites and then begin to remember the rest of the trip details that were needed to complete the trip log.

Information provided on each respondent's map was transferred into digital form using ArcView. Mistik Management provided digital files for the region including lakes, rivers, roads, trails, FMA and other planning unit boundaries. This information was used as geographic references for developing general hunting area and hunting trip locations. Although individual

[3] The map provided was approximately 6x3 feet in size so that detailed information could be recorded.

trips were digitized, to ensure confidentiality, the data were aggregated for each community. Aggregating the individual general hunting areas by community also helped determine the geographical extent of hunting trips for each community. General hunting areas for several communities overlapped, but for the most part they followed the boundaries of Fur Conservation Areas which are based on traditional trapping areas.

Special Sites Map / Information

Respondents were also asked to mark 'special sites' such as salt licks, cabins, areas of exceptional moose habitat, burial sites, and avian nesting areas on the maps.[4] These maps are similar to those generated in traditional land-use mapping exercises and reflect the traditional ecological knowledge of the hunters (MacKinnon et al, 1999; Pyc, 1999). This information provided a spatial record of characteristics that may be important in explaining hunter site choice. We employ some of this information in developing measures of the attributes of hunting sites.

Stated Preference Information

We extend existing studies on Aboriginal hunting (e.g. Winterhalder 1983, 2001; Feit 1987) by incorporating stated preference methods into our survey. We used a choice experiment approach to investigate how Aboriginal people in the region select where they hunt and how their behavior might change in response to changes in moose, forestry, costs and other factors.

The design of the choice experiment began with a list of hunting site characteristics used in earlier choice experiments designed to capture preferences of southern hunters for hunting sites in central and northern Saskatchewan. This list of potential hunting site characteristics was presented to a focus group; the appropriateness of each attribute was discussed and culturally appropriate levels were determined. This set of attributes was further vetted through an elder hunter who after some discussion approved the list. From these approved attributes a choice experiment was designed.

The attributes themselves did not differ radically from earlier designs used in studying

[4] Most of these data are not used here for modeling purposes, but these individual maps were compiled into one and this was provided to Mistik Management to be used when drafting their forest harvest plans. We also derived "community-level" special sites maps and presented these to each community during presentations in June 2001. This procedure assisted in the process of building trust during the data collection exercise.

non-aboriginal hunters (e.g. Adamowicz et al. 1997; Boxall and Macnab 2000). However, the levels of the attributes did (see Table 1). In particular, the levels for the distance travelled and the mode of transportation attributes differed from earlier surveys reflecting the fact that Aboriginal hunters live in their hunting regions and that past cultural practices influence the mode of transportation for some of them.

The prototype choice experiment was initially text based, similar to choice experiments used in mail surveys of licensed hunters in the south (e.g. see Boxall and Macnab, 2000). One elder informant, who was conversant in English but had difficulty reading, found that reading the survey and discerning the specifics of the choice experiments difficult. It was decided that an illustrative approach would be more appropriate in this setting. Photographs were used for attributes for which a picture would easily illustrate its meaning, such as time since harvest and access to the hunting site. More detail on the choice experiment can be found in Dosman et al. (2002) and Haener et al. (2001b).

Socio-demographic and cultural data

In addition to the information related to actual hunting behavior and the responses to the choice experiment, we also collected socio-demographic data including age, community born, gender, education, marital status, number of children, employment status, partner's employment status, and aboriginal status. During the development of the survey tool we were informed that it would be culturally inappropriate for us to ask respondents to report their annual income. We thought annual income could be imputed from the respondent's employment status and industry in which they worked. However, it became evident during the interviews that over the course of a year many respondents were employed in a series of jobs that last for a few days to several weeks or months in many different industries ranging from forest fire fighting to road construction to forestry work. A much more detailed employment record for the year would be needed to be able to impute individual income levels.

These features have significant implications for the accuracy of value of time calculations derived from travel distances using standard economic approaches (i.e. travel cost models). Since many individuals in our sample changed their employment-related activities over the year we use the average male income for the region in our computation of a wage rate. We attained average male income levels from the national aboriginal census (Statistics Canada, 1998).[5]

Methods

Descriptions of the behavior of boreal aboriginal hunters in the anthropological literature suggest that they have considerable knowledge of moose biology and that their hunting behavior represents decisions that optimally provide opportunities for harvest. For example, Winterhalder (1983) describes frequent use by hunters of areas in proximity to water and forest areas recently disturbed by fire, and that they adjusted their hunting behavior seasonally to match changes in habitat use by moose. These features correlate well with biologists' analysis of preferred moose habitats (e.g. Saskatchewan Forest Habitat Project 1991). Feit (1987) suggested that Cree hunters use indicators of moose populations to guide hunting decisions. This information suggests that models of hunting site choice by aboriginal hunters should incorporate such indicators and their potential change as a result of landscape alteration through timber harvests.

Our modeling framework is illustrated in Figure 2. We employ hunter knowledge and forest characteristics to develop a model of moose population or abundance. This model provides measures of one of the most important attributes of the sites. In addition to information on moose populations, forest landscape and road network characteristics are directly used as explanatory variables in a revealed preference model. We then employ a combination of revealed preference and stated preference data to generate a joint model of hunter preferences. Each of these components will be outlined below.

Spatial Resolution

Since our objective was to develop a hunting site choice model that could be used to simulate the effect of landscape changes on behavior, a spatial framework must be chosen which incorporates landscape and hunting attributes as well as trip behavior. For this spatial scale the Operating Area (OA) was selected as the unit of analysis. Mistik Management considers the OA as the smallest spatial unit used to plan forest harvest operations in the FMA. Hunters in our sample took trips to most of the 450 operating areas in the FMA, as well as some outside the

[5] Since many individuals in our sample changed their employment related activities over the year one could develop a model explaining the changes as a function of characteristics of the opportunities (wages, etc.) and the season of the year (an indicator of the value of non-timber based activities). This would provide a measure of the implied

FMA.

From the digital files provided by Mistik Management, the following variables for each OA were developed: lake area (ha), length of rivers (km), length of road (km) by class of road (1-8), and size of the OA (ha). For the OAs in the FMA the following forest landscape characteristics were available: crown closure class (4 classes ranging from open to closed based on % cover), age class, the area of recent (5 years or less) and older (> 5 years) timber harvests, the area burned in forest fires, non-forest area (e.g. muskeg), productive forest area, and the area not subjected to previous timber harvest operations.

Moose Population / Abundance Model

One important landscape attribute that was not available was the abundance and availability of moose. Usually aerial survey transects are used by biologists to estimate moose abundance, but these had not been completed in the study region. To overcome this gap in the data, and following the research by Feit (1987), information provided by the hunters was used to develop a moose abundance indicator for each OA. To create this indicator OAs were identified in which respondents indicated there were exceptional areas for moose. The information on moose populations and forest landscape attributes were used to construct a model of moose populations. Given the discrete nature of this variable (exceptional habitat or not) a logit model was used to estimate the probability that any OA in the FMA had exceptional moose habitat.

Landscape features related to moose habitat preferences discussed in the biological literature were included in the model (e.g. variables used to develop moose habitat suitability indices in the Saskatchewan Forest Habitat Project, 1991). These included the density of rivers, areas of disturbance from fire or previous timber harvests, the area of standing water, the area of muskeg, and the area of forest classified as relatively open (crown closure 0-25%). Other variables were chosen that were related to human use and perception such as the number of cabins within 10 km of an OA and the presence of a salt lick within 10 km of the OA.

The logit model with the best fit is reported in Table 2. The influential explanatory variables were recent anthropogenic disturbance (new cuts), the presence of salt licks, and those related to aquatic habitat (muskeg and water). The crown closure and river density variables

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reservation wage associated (and value of time) with non-timber based activities. However, our data were not detailed enough to construct such an analysis.

were significant at the 10% level. This model was used to estimate the probability that each OA in the FMA would contain exceptional moose habitat.

<u>Choice Model Development</u>

The interest in this paper is in developing a model to explain why hunters visit certain OAs over others and how their choices might be affected by timber harvesting. This information represents discrete choice data, which can be analyzed using econometric methods based on random utility theory (Louviere, Hensher and Swait 2000). This theory maintains that the utility an individual derives from visiting an alternative site, *i*, is considered to be associated with the attributes of that alternative. This utility function (U_i) can be represented as $U_i=V_i+e_i$ where V_i signifies a deterministic component and e_i an unobservable or stochastic component.
V_i can be characterized by its attributes. Thus, $V_i = b_k X_i$ where X_i is a vector of k attributes associated with alternative *i* and b_k is a vector of parameters or taste weights. If the distribution of the stochastic components is characterized as IID Gumbel, the conditional probability of selecting alternative *i* from a set, *C*, of alternative sites is:

$$(1) \qquad \text{prob}(i) = \exp(\mu\beta_k X_i) \Big/ \sum_{j \in C} \exp(\mu\beta_k X_j)$$

where *m* is a scale parameter and *C* is the choice set.

When a single set of data is used to estimate a model, *m* is confounded with the parameter vector and cannot be identified. However, in models in which multiple data sources are merged to estimate the parameter vector, the scale of one dataset can be estimated relative to the other (Louviere, Hensher and Swait 2000).

We anticipated that the revealed preference attribute data would not be sufficient to capture the preferences of the hunters. In part this arises because data for some important attributes were not available (e.g. moose populations). In addition, the revealed preference attributes are likely correlated and confound effects. For example, the effect of forest harvesting on the aesthetics and appearance of a site would be confounded with the impact on moose populations. Finally, it appears that joint stated – revealed preference models can outperform revealed preference models in predicting actual behavior when the stated preference data are carefully collected (Haener, Boxall and Adamowicz, 2001a). Therefore, both data types are employed in modeling the trip locations of aboriginal hunters.

Since the SP data were generated from a controlled design, the number of alternatives in the choice set, *C*, was 3 and the attribute levels (Table 1) were predetermined. However, this is not the case for the RP data. For the RP data, the choice set for each community determined by the survey was different, ranging from 30 to 207 OAs. To facilitate estimation, each community's choice set size was reduced to 30 OAs by randomly selecting a subset of the relevant OAs for each trip from the full choice set. This procedure has been shown to produce parameters that are not significantly different from those derived using the full choice set (e.g. Parsons and Kealy, 1992).

The landscape attributes used in the models and their coding are described in Table 3. Since we combined the RP and SP data in a joint model, several variables from the RP data and SP data were transformed so that their coding was commensurate. Note that there is not complete overlap between the RP and SP data series. The encounters variable, for example, exists only in the SP data. The joint model combines data for the attributes common to both sets of data, while still allowing the coefficients of the attributes unique to the RP and SP data to be estimated. The model we use for simulation is based only on the attributes common to both models and one variable unique to the RP data (i.e. cabins). Since the SP data are based on an orthogonal design we can employ a subset of the attributes in estimation and simulation without significant concern about specification error. The combined variables and their resulting codes are listed in rows 2 to 7 of Table 3. The remaining rows show the variables that are unique to the RP and SP datasets.

In modeling hunting site choice, travel cost is commonly used as proxy for the cost of visiting areas (e.g. Adamowicz et al. 1997; Boxall and Macnab 2000). Following the standard procedures in the travel cost literature it is assumed that travel cost is a function of out of pocket expenses related to travel distance and the time costs of traveling (e.g. Boxall et al. 1996). Travel distance was included in the design of the SP choice experiment. However, it was necessary to calculate travel distances for the RP data. To estimate these distances, the shortest road distance between each community and the centroid of each OA in the community general hunting area was determined using the GIS. In several parts of the FMA the road network is sparse, therefore travel distances include the distance by road and the remaining 'non-road' distance required to reach the operating area. The 'non-road' distance also serves as an indicator of the remoteness of the operating area. The operating cost of vehicle use associated with the road distance was estimated at $0.589/km (reported by the Canadian Automobile Association). The operating costs associated with the non-road portion of the distance was assumed to be 3 times this figure, as supported by information suggesting that the fuel mileage of off-road vehicles and snowmobiles is about one-third that of a car or truck.[6]

The standard means of incorporating the value of travel time was also used. We assumed an average speed of 80 kph and use one-third the estimated wage rate for the region. The wage rate was determined by dividing the average male income for the region by the total number of work hours in a year (assuming a 40 hr work week). We recognize that this method of valuing time may be inappropriate for this context and suggest that trade-offs associated with pursuing subsistence activities need to be further investigated.

Results

Choice Model Parameters

The parameter estimates for the joint RP-SP model and the corresponding RP and SP models are reported in Table 4. The RP model only has parameters for those attributes that could be related to the spatial information provided by the hunters and Mistik Management. For the SP model, parameters displayed are only for those attributes used in the choice experiment. The joint model contains parameters for all of the characteristics in the RP and SP models, but recall that these parameters are constrained to be equal across the two sets of data. Since the joint model provides the most complete information on attributes, it is discussed in detail below. However, it should be noted that the signs of those parameters identified as statistically significant are consistent across the three models but for one exception.[7] The dummy variable on new cuts (recent harvests) in the RP model is positive and significant, likely a result of confounding between harvest, access and moose populations.

[6] This information is reported by Kreag and Moe (2002) and at http://www.labaronssports.com/pages/mancominiatv.htm

[7] A likelihood ratio test was performed to examine whether the RP and SP parameter vectors are significantly different that those of the joint model. The results ($\chi 2$=76.8, 4 df.) suggest that the joint model is significantly different. This test, however, is recognized in the literature as being rather strict and it appears that only one or two parameters drive this result. Nevertheless, we plan on further research to investigate this issue.

In the joint model the travel cost and the encounter parameters are negative and significant. This suggests that the hunters prefer to hunt closer to their communities and that they would prefer fewer encounters with other hunters while hunting. The cabins, water access, and the moose abundance indicator variables are positive and significant. These findings suggest that the hunters prefer to hunt in OAs with or near cabins, that have good water access, and that contain high moose numbers. Note, however, that the access variables, while positive, are statistically insignificant.

The parameters on the timber harvest variables in the joint model suggest a preference pattern where newly harvested areas are avoided, while those with older are slightly preferred to new harvest, but not as desirable as areas with no harvests (the base). Since moose abundance is also related to forest disturbance patterns (see the newcut variable in Table 2), the choice model parameters suggest a complex pattern of preferences for forest age and disturbance. It appears that there are amenity effects for the forest condition independent of the forest effects on moose abundance. Thus, recent timber harvests have a negative effect on utility through the new cut dummy in the joint model, but have a positive effect on utility through their beneficial impacts on moose abundance.

Using the Model to Simulate the Effects of Forest Landscape Changes

An advantage of using choice models to examine preferences over attributes is that the model can be used to examine changes in choice behavior when attributes of one or more alternatives in the choice set change. This can be done in a probabilistic framework using equation 1 above. In addition, given that a cost variable is included in the model, monetary measures of economic welfare can also be associated with these changes in attributes (see Hanemann, 1982). These features were used to simulate the effects of two different timber harvesting plans on the distribution of hunting trips in the general hunting areas of two communities in the study and the associated economic impacts.[8] Once these effects are understood, we then consider whether actions to improve moose populations in certain areas would "compensate" for the effects of harvesting.

Simulation of Timber Harvesting

[8] We do not identify these communities in this paper for reasons of confidentiality.

To determine the influence of timber harvesting on hunting behavior two harvesting scenarios for two communities were imposed on the current distribution of trips in the relevant general hunting areas. The first scenario uses Mistik Management's harvesting plan (see the dispersed plan in Fig. 3). According to this plan, about 3000 ha of forest, distributed in 19 OAs, will be harvested in the general hunting area for community 1, and about 6000 ha of forest, distributed in 20 OAs, will be harvested in community 2.

A strategy that has been receiving significant attention in forest management recently is the zoning of land areas and the concentration of activities within zones. Rather than attempting to practice sustainable forest management "everywhere" on a landscape, foresters, for example, could emphasize timber production in one zone, leave another zone for wildlife and landscape protection and manage using multiple use principles in a third. This zoning strategy is often referred to as the TRIAD (a three zone strategy involving an intensive forest management zone, a protected area and a multiple use management zone). It corresponds to the notion of increasing management effort and capital investment in those regions best suited for forest management (Vincent and Binkely, 1994). We consider an analogous strategy here, however the zoning considered is a concentration of forest harvesting and implicitly identifying zones where hunting could be the main land use strategy.

Based on the zoning concept and considering the distribution of uncut forest in the OAs, an alternative forest harvesting plan involving a more spatially concentrated harvest is used for comparison with the dispersed harvesting plan. The 3000 ha of dispersed harvesting planned for the general hunting area of community 1 is reallocated into 3 OAs, and the 6000 ha of harvesting planned for the general hunting area of community 2 is reallocated into 4 OAs.

If the total number of trips taken in each community in a year is held fixed, then following the timber harvests the distribution of trips across the OAs in each community's general hunting area will change. These changes result from the effects of harvesting on both moose habitat and hunter preferences through changes in the new cut variable in the moose abundance model (Table 2), and changes in the new cut dummy variable in the choice model (Table 4).

Figure 3 shows those OAs that experience relatively significant changes in the predicted distribution of trips following the dispersed and concentrated timber harvests. The change in trips is measured by the percentage change in trips taken to the operating area (i.e., (post-harvest trip –

pre-harvest trip)/pre-harvesting trips*100). The response to the dispersed forest harvesting plan shows that the most significant impact arises in OAs that have not been previously harvested. Hunting trips to these sites would decrease by 30 to 40 percent. Because most of the forest harvesting in the area of community 2 occurs on such lands, the impacts are more severe on hunters in this community. Hunters are expected to move to other areas, but they reallocate over a large number of OAs instead of simply switching to a small number of other sites.

Employing a concentrated forest harvesting plan significantly reduces the impact on hunters. In part this is because of the decreased number of OAs affected, but it is also because most of the sites selected for concentrated harvests had already experienced some degree of timber harvesting. As one would expect, concentration appears to result in an improved overall outcome.

The welfare impacts[9] associated with the timber harvesting plans in each community are presented in Table 5. The harvesting effects are more pronounced in community 2 and are insignificant in community 1. As mentioned above, the reason for this difference is that timber harvesting has occurred near community 1 for a number of years. However, timber harvesting is just beginning near community 2. Therefore, hunters in community 1 are already hunting in areas containing recent cutblocks, and further harvesting in this area has a limited effect on aboriginal hunters using the area. In community 2, however, most areas visited by hunters in the community have never been subjected to forestry operations. As a result, timber harvests in this area causes the hunters to substitute away from the newly cut areas. The hypothetical concentrated harvesting plan mediated the negative effects of harvesting in community 2. An unexpected result occurs in community 1. Dispersed harvesting results in a positive welfare effect as the positive effect on moose populations dominates the negative effect of harvest on aesthetics. However, the concentrated harvests do not positively affect as many sites and result in a very small net loss in welfare. Both these effects are quite small in per trip and aggregate terms.

Resource Compensation as an Alternative to Monetary Welfare Measures

Forest managers have some ability to counteract the effects of forest harvesting by compensating "in-kind". This could involve enhancing the hunting related attributes of sites

[9] Hanemann's (1982) welfare measure was used to assess the economic effects of these harvest plans in each community.

known to be preferred by hunters. This strategy is somewhat analogous to the concept underlying zoning in that land use specialization is being employed. Strategies that forest managers could employ include removing access (to reduce encounters and congestion), investing in wildlife habitat improvements, or, with cooperation from fish and wildlife management agencies, limiting access by non-aboriginal hunters to certain OAs. We examine resource compensation in terms of investments in wildlife habitat that generate increased moose populations in select OAs.

Improvements in moose populations could result from restricting human access to lower the moose mortality rates from hunting, or landscape alterations through forest management to provide more moose habitat (e.g. Saskatchewan Forest Habitat Project. 1993). In this study it is assumed that actions can be taken to affect moose abundance and that these measures will affect the moose abundance measure described above and in Table 2. We also consider the possibility that different levels of intensity of investment in increasing moose populations could occur. The first is a low intensity plan that increases the probability of an OA having exceptional moose abundance to 0.20. The second is a high intensity plan that will increase the probability to 0.50.

The model of hunting preferences along with the information on site attributes provides a way to determine the best area to invest in habitat improvements to increase moose populations. To determine which OAs were the best candidates for moose improvements, the moose abundance probability was increased to the target level (i.e., 0.2 or 0.5) at each individual OA. For each change the change in total welfare per trip was calculated. The OAs were then ranked according to the change in total welfare per trip resulting from improving moose probability at that site. To determine how many of the OAs require improvement, the effect of improving moose habitat is simulated for the top 2 ranked sites, then the top 3 ranked sites, then the top 4 ranked sites, etc. until the welfare impact is just enough to offset the impact of the timber harvest plan. This strategy is similar to that employed in resource compensation efforts in the Natural Resource Damage Assessment literature (e.g. Desvousges, MacNair and Smith, 2000).

The results of these simulations for each community are reported in Table 6. For community 1, in which considerable harvesting has occurred in the general hunting area in the past, no OAs required improvement to offset the negative impacts of the timber harvest plan since the net impact of timber harvest was positive. Of course the impact of the plan on hunters in this area was also judged to be relatively minor. However, in community 2, 13 OAs required management intervention to achieve improvement in the low intensity scenario, and 1 OA was required in the high intensity scenario. Thus, in the area that has not experienced forestry operations in the past, considerable intervention is required to compensate hunters.

This leads one to question what are the features of those OAs in which intervention is required for compensation. For community 2, where many OAs have never been harvested, the best candidates for moose enhancement are OAs where no cutting occurred in the past and no new harvesting occurs. Other candidate OAs would be those with more cabins nearby, are most accessible by water, and as measured by the moose abundance indicator model, moose habitat is relatively poor.

Discussion and Conclusions

Increasing importance is being placed on recognizing the values of Aboriginal People in resource management decisions. In the context of forest management in Canada, Aboriginal People are often significantly affected by forestry decisions. Attempts to incorporate Aboriginal People's values into management have included various co-management strategies and consultation strategies but even these have not necessarily addressed the challenge adequately. Monetary compensation for the impact of industrial activity on traditional land use activities has been used in some cases, but the methods of determining such monetary compensation are questionable.

In this paper we make use of a unique data set that allows us to assess the impact of forest management on Aboriginal hunting activities. We employ a behavioral approach in order to better understand the tradeoffs that hunters make and the implicit value of changes in the environment. We use this behavioral model to assess impacts of forest harvesting and to develop monetary measures of this impact. We also use this model to examine alternative strategies for managers including resource compensation and zoning.

The first conclusion arising from our study is that investment in the data collection component is critical for the collection of data on use of non-timber resources by Aboriginal People. Without the investments made to collect the data in an atmosphere of trust and reciprocity our study would not have been possible. The unique character of our study area that includes a forest management agency that has previously invested in co-management relationships with the Aboriginal People should also not be undervalued. It is unlikely that very many forest management contexts would involve such characteristics. Nevertheless, if the values of Aboriginal People are to be effectively incorporated into management, such investments are necessary.

In addition to investing significantly in data collection we also made the choice to obtain and employ stated preference data, revealed preference data and hunter perceptions / knowledge. We believe that the use of traditional ecological knowledge of the hunters improved our ability to model choice. We also believe that the use of stated preference data is important in contexts such as these where the revealed preference data may be highly correlated and where new management strategies may extend landscape conditions beyond those that are currently being experienced. However, issues remain regarding econometric implications of our sequential estimation strategy, the appropriate weighting of RP and SP data in estimation, and the degree to which understanding and behavioral prediction is improved by combining data sources.

A second conclusion is that it is clear that Aboriginal hunters do make trade off decisions that are consistent with an underlying optimization framework. This conclusion is consistent with the research of Winterhalder (2001) and others who examine aboriginal hunter behavior in an optimal foraging framework. Thus, aboriginal hunting behavior can be used to develop measures of value associated with environmental attributes. This supports the use of behavioral studies in the Aboriginal context. However, it is not clear that we have accurately captured the behavioral relationships. In particular, the tradeoffs regarding time use require more investigation. Aboriginal hunters respond to opportunities, both market and non-market, that arise over time. A more careful assessment of the choice of these opportunities could provide valuable insights into the implicit value of time in hunting activities. Hunting activities are not recreation for many Aboriginal People. The choice to invest time in hunting rather than market wage opportunities reflects a type of reservation wage that could be identified from detailed activity data. This we feel is an avenue for future research that could help identify the importance, both culturally and materially, of hunting within Aboriginal societies.

While estimated monetary measures of welfare are reported in this paper, we believe that our investigation of resource compensation and zoning (concentrated forest harvesting) could be more useful to resource managers. Increasingly it is recognized that wide scale multiple use forestry may not be the best way to manage forests and that specialization may be an improved management model. Our results suggest that investments in habitat at a few sites could offset the impacts of forest harvesting. It would be interesting to examine the costs of such investments versus the monetary compensation required to offset these impacts. However, while resource compensation addresses the impacts in total, it does not address the distribution of impacts. Such distributional impacts have been identified as a difficulty in resource compensation exercises or indeed in any form of benefit cost analysis that does not use money as the numeraire (Brekke, 1997).

The distribution of impacts across the population of Aboriginal People has been ignored in this study. That is clearly a limitation of our approach to this point. In previous research the heterogeneity across Aboriginal Peoples has been highlighted as a significant feature in the data (Haener et al. 2001b). Incorporating heterogeneity into our modeling approach through the use of mixed logit models or finite mixture models (e.g. Boxall and Adamowicz forthcoming) will undoubtedly improve our understanding of behavior and provide us with improved measures of welfare and resource compensation. However, incorporating heterogeneity will also increase the complexity of the measurement of welfare and resource compensation.

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Table 1. Definition of hunting site attributes for the choice experiment administered to the Aboriginal hunters.

Attributes	Levels
How far hunting site is from home.	10 km
	50 km
	100 km
	200 km
How many people you see at the hunting site.	Nobody else, except other in my hunting party
	Other people
How many signs of moose you will see each day.	Signs of less than 1 moose per day
	Signs of 1 to 2 moose per day
	Signs of 3 moose per day
	Signs of more than 4 moose per day
How hunters travel to the site.	On foot without trails or cutlines.
	By quads on old logging roads.
	By 4-wheel drive on new logging roads.
	By boat through interconnected lakes.
How long it has been since the site was harvested.	Site just harvested.
	Site logged 3 to 5 years.
	Site logged 10 to 15 years.
	No evidence of logging.

Table 2. Parameter estimates for a logit model used to estimate the probability that an Operating Area (OA) contains high moose populations.

Variable	Description	Parameter estimate	*t*- statistic
Constant		-3.0948	-10.88
Crown A	Percent forest area in the OA with crown closure 0 to 25% density	-16.2631	-1.92
Salt licks	A dummy variable indicating presence of salt lick(s) within the OA	0.7641	5.10
Water	Percent OA area covered by water	0.0262	2.35
Muskeg	Percent OA area classified as muskeg	0.0272	2.35
New cut	Percent OA area classified as new cuts	7.8367	4.06
River density	Density of rivers in the OA	0.1810	1.87

Table 3. A description of variables used to estimate choice models using revealed (RP) and stated (SP) preference information from aboriginal hunters in the NorSask FMA.

Common Variables	Coding	Revealed preference data	Stated preference data
Travel cost	$'00	Road distance was transformed to a travel cost as follows: (2*(road distance +3*non-road distance)*(0.589+(income/(3*90*2040)))/100*	
Moose abundance	0 - 1	Based on predicted probability from the OA moose habitat model in Table 3	0.05 - signs of less than 1 moose /day 0.375 - signs of 1-2 moose/day 0.750 - signs of 3 moose/day 1.000 - signs of more than 4 moose/day
New cut dummy	0, 1	1 = new cuts area < old cut area and < 90% of area uncut; 0 otherwise	Site harvested 5 or fewer years ago
Old cut dummy	0, 1	1 = old cuts area >= new cut area and < 90% of area uncut; 0 otherwise	Site harvested 10 to 15 years ago
No cut	Base	= > 90% of the area is uncut	No evidence of timber harvesting
Water access dummy	0, 1	1 = a river intersects the OA or more than 1% of the OA is covered by a lake; 0 otherwise	OA is accessible by water.
Cabins	0 - 5	Number of cabins in or within 5 km of the OA	NA
No hunt constant		NA	1 = stay at home instead of hunting
Encounters	1, -1	NA	1 = Other people are encountered
New access	1, 0	1 = access via new logging roads	NA
Old access	1, 0	1 = access via old logging roads	NA

* Where income represents the average male income for each community reported in the census.

Table 4. Parameter estimates for the RP, SP and joint RP-SP models.

Variables	RP model		SP model		Joint model	
	Parameter	*t* statistic	Parameter	*t* statistic	Parameter	*t* statistic
Travel cost	-0.1753	-3.357	-0.6721	11.32	-0.6868	10.563
Moose probability	1.5336	7.872	0.8295	5.788	0.9821	6.536
New cut dummy	0.1703	2.031	-1.2783	11.05	-1.1131	8.113
Old cut dummy	-0.0756	0.232	-0.5055	3.577	-0.4032	2.669
Water access dummy	0.2177	2.482	0.4703	3.449	0.5395	3.866
Cabins	0.3154	11.505			1.7535	3.798
No hunting dummy			-2.0024	11.048	-1.7958	9.232
Encounters			-0.2464	4.724	-0.2442	4.389
New Access			0.1159	0.84	0.1568	1.068
Old Access			0.0868	0.628	0.1089	0.741
Ln(μ)					-1.5619	
Log Likelihood	-3124.5			-826.3		-3989.2
ρ^2	0.04			0.23		0.08
LL Sum				-3950.8		

Table 5. The changes in economic values associated with two harvesting plans on hunting trips taken by aboriginal hunters in two communities in the NorSask FMA.

Harvest Plan	Per trip Values		Total Values	
	Community 1	Community 2	Community 1	Community 2
Dispersed Harvesting	$0.06	$-1.18	$150.96	$-2791.88
Concentrated Harvesting	$-0.01	$-0.108	$25.16	$-189.28

Table 6. The number of operating areas (OA) in which actions to improve moose abundance are required to compensate aboriginal hunters for the planned dispersed timber harvest.

Intensity of Effort	Number of OAs required	
	Community 1	Community 2
Low	0	13
High	0	1

Figure 1: Maps of Canada and of Alberta and Saskatchewan showing the locations of the NorSask FMA

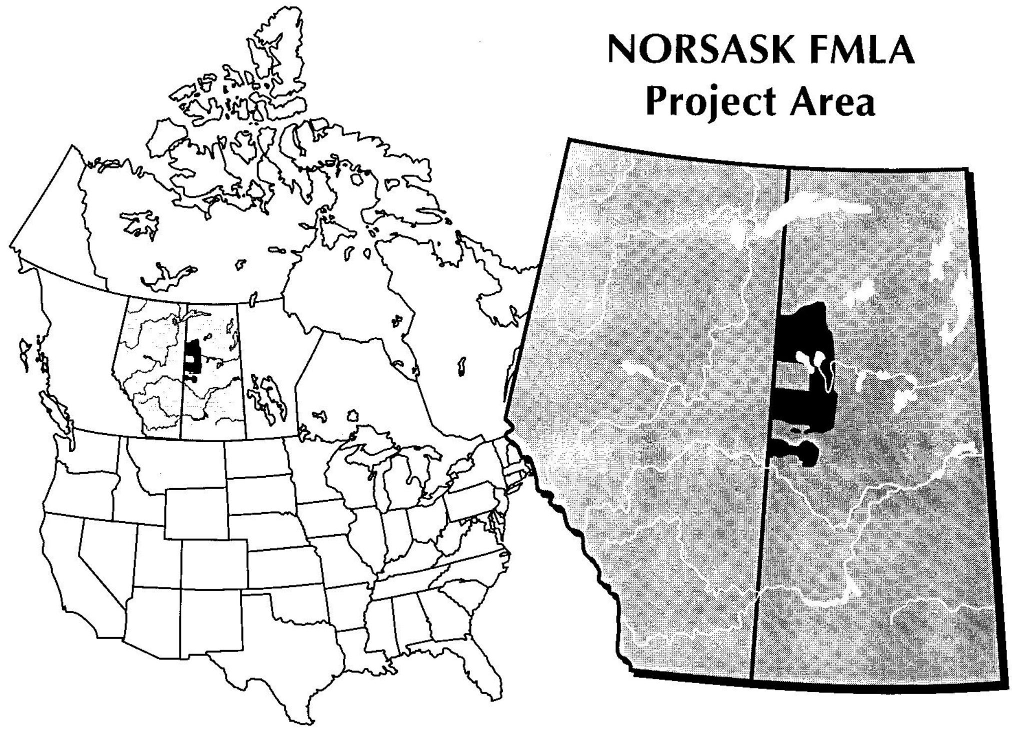


Figure 2: A diagram summarizing the strategy used in modelling aboriginal hunting trips in the NorSask FMA.

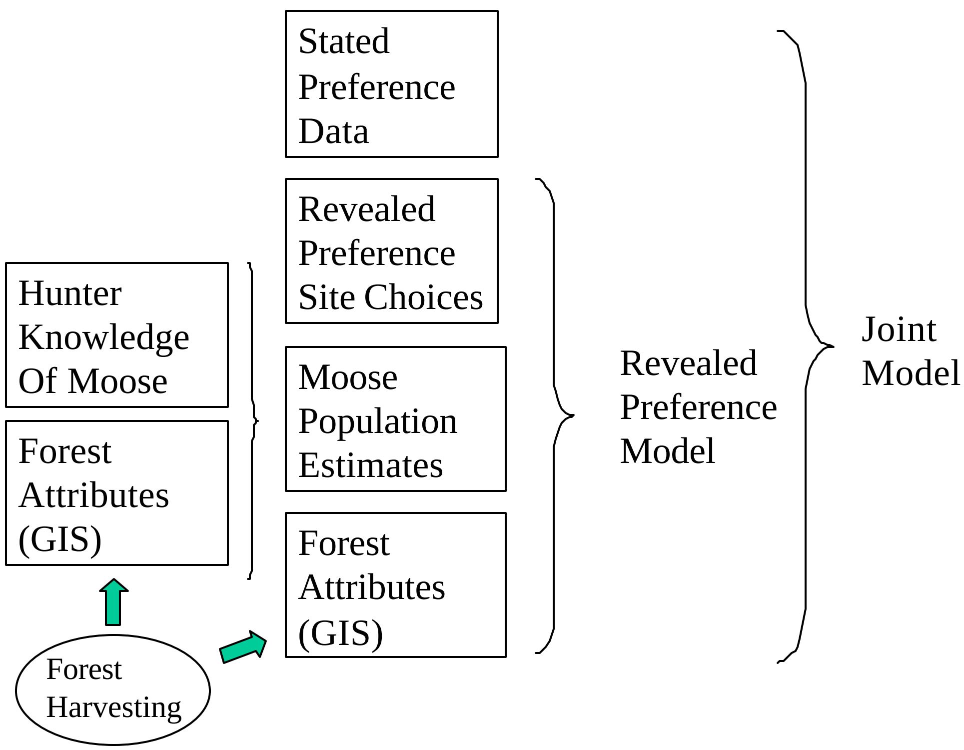
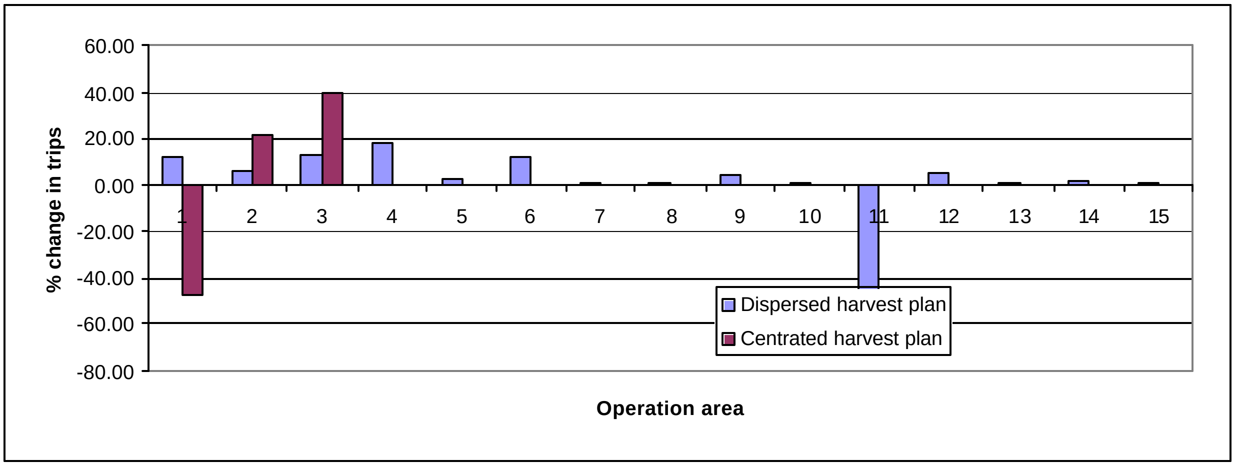


Figure 3. Predicted responses of Aboriginal Hunters in two communities in the NorSask FMA to two forest harvesting plans.

Community 1



Community 2