A RECREATIONAL DEMAND MODEL OF WILDLIFE-VIEWING VISITS TO THE GAME RESERVES OF THE KWAZULU-NATAL PROVINCE OF SOUTH AFRICA

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Centre for Social and Economic Research
on the Global Environment
University College London
and
University of East Anglia

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Abstract

In recent years, random utility models (RUMs) have become an increasingly popular approach to estimating the welfare benefits derived by visitors to recreational sites. Researchers using such models have tended to concentrate on the choice between sites; explaining a visitor's decision by means of the different qualities of the available sites and the different costs of travelling to those sites. This is all well and good for 'day trips' but for recreational trips characterised by visits lasting a number of days, concentrating solely on the choice between sites may be a gross oversimplification. For such 'away-breaks', a visitor's choice of accommodation and length of stay may be just as important as the qualities of the site and the length of the journey in determining the costs and benefits that result from the trip. This paper describes the application of a RUM known as a nested multinomial logit model (NMNL), which distinguishes the three dimensions of choice that characterise away-breaks; duration of stay, choice of recreational site and choice of accommodation type.

Four costs are important in determining choice for such trips; the cost of travel to the recreational site, the cost of accommodation at the site, the cost of time whilst travelling and the cost of time whilst on-site. Previous applications have frequently assumed that travel time can be valued at some exogenously determined proportion of the wage rate, whilst at the same time ignoring the value of time spent on site. The specification of the indirect utility function in the model presented here, allows for the value of time to be inferred from the data by estimating the proportion of the wage rate that most appropriately values a unit of time spent in different activities.

The model is applied to a unique dataset that records details of trips made by domestic households to the game reserves of the KwaZulu-Natal province of South Africa. These trips are typical of away-breaks, since visitors tend to travel fairly large distances to visit the reserves and typically stay one or more nights on site. Each of the game reserves affords visitors different wildlife-viewing opportunities and provides a variety of accommodation facilities that vary greatly in their quality and price. Geographical information system (GIS) techniques have been used to establish exact door to gate distances and provide accurate

estimates of travel costs and travel times that take account of assumed road speeds. GIS techniques have also been employed to garner socio-economic data on the households in the dataset. One further novel feature of the data is the use of complex computer algorithms to accurately establish the choice sets faced by individual households.

The three-level NMNL model is estimated using a full information maximum likelihood (FIML). The results of the analysis support the work of De Serpa (1971) in that they suggest that recreationists have a positive willingness to pay to save time in travelling to a reserve, but as would be expected, are not willing to pay anything to save time spent on site.

The model is used to calculate welfare estimates for continued access to the different game reserves. Average per-trip estimates of the consumer surplus enjoyed by domestic visitors range from around $15 for one reserve, up to almost $50 for another. Boot-strapping techniques have been employed to calculate standard errors for these benefit estimates.

1. Introduction

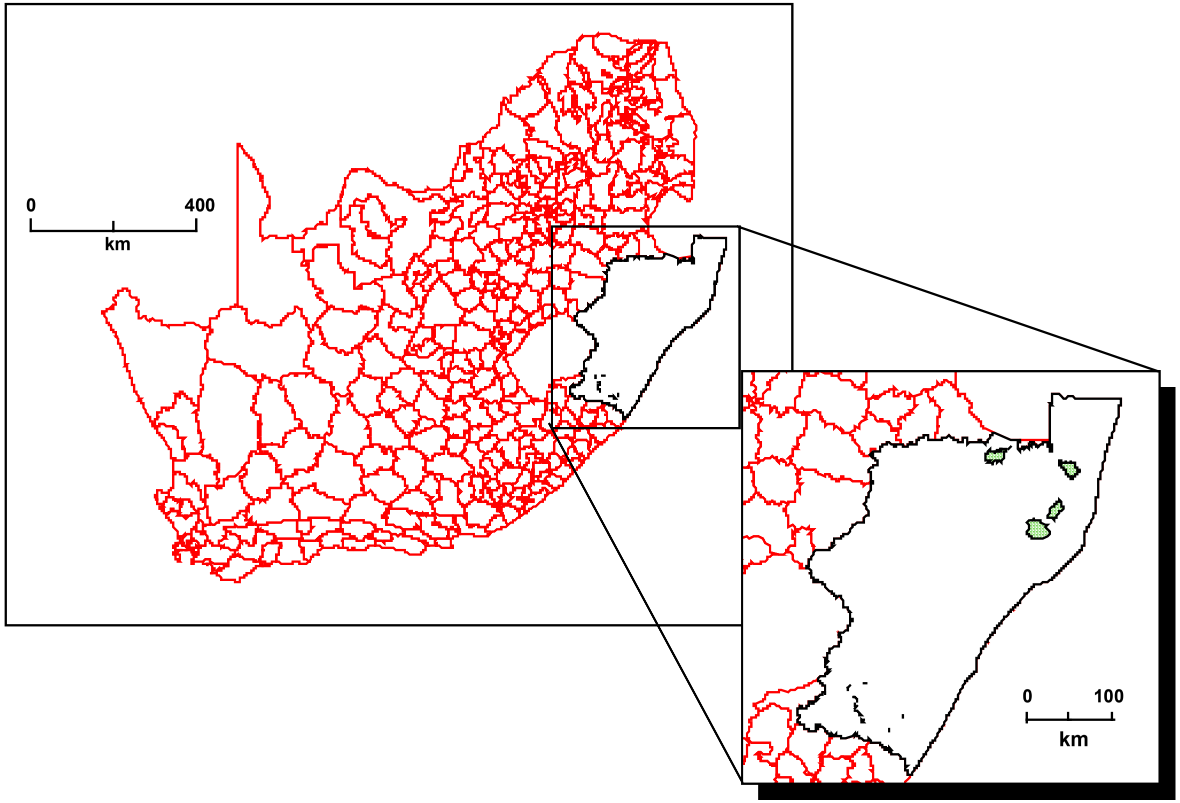
The South African Province of KwaZulu-Natal sits in the south-eastern corner of the African continent (see Map 1). Despite South Africa's relative development, the area boasts an impressive diversity of natural habitat. In the west of the province, bordering Lesotho, are the mighty Drakensburg Mountains, a unique montane ecosystem and the last redoubt in Southern Africa of the bearded vulture. On the north-eastern coast can be found the huge inland lagoon of St.Lucia home to an amazing variety of birds and wildlife and a recently declared UNESCO World Heritage site. Further north still is Sodwana Bay, the most southerly extension of coral reefs on the African continent. Whilst throughout the north-east of the province are vast areas of wilderness home to that most archetypal of African wildlife; the savannah megafauna, including elephants, rhinos, buffalo, antelope and big cats.

KwaZulu-Natal boasts an extensive system of protected areas managed and maintained by the KwaZulu-Natal Parks Board (KNPB). The protected area network varies from small, local nature reserves a few hundred hectares in size through to internationally renowned game reserves covering areas of several hundred square kilometres. Amongst the latter are the game reserves of Hluhluwe, Umfolozi, Mkuzi and Itala, which form the focus of this study. The KNPB's responsibilities are twofold; (1) to protect and conserve the natural habitats and wildlife in these protected areas and (2) to provide facilities that allow members of the public access to the reserves in order to enjoy their natural heritage.

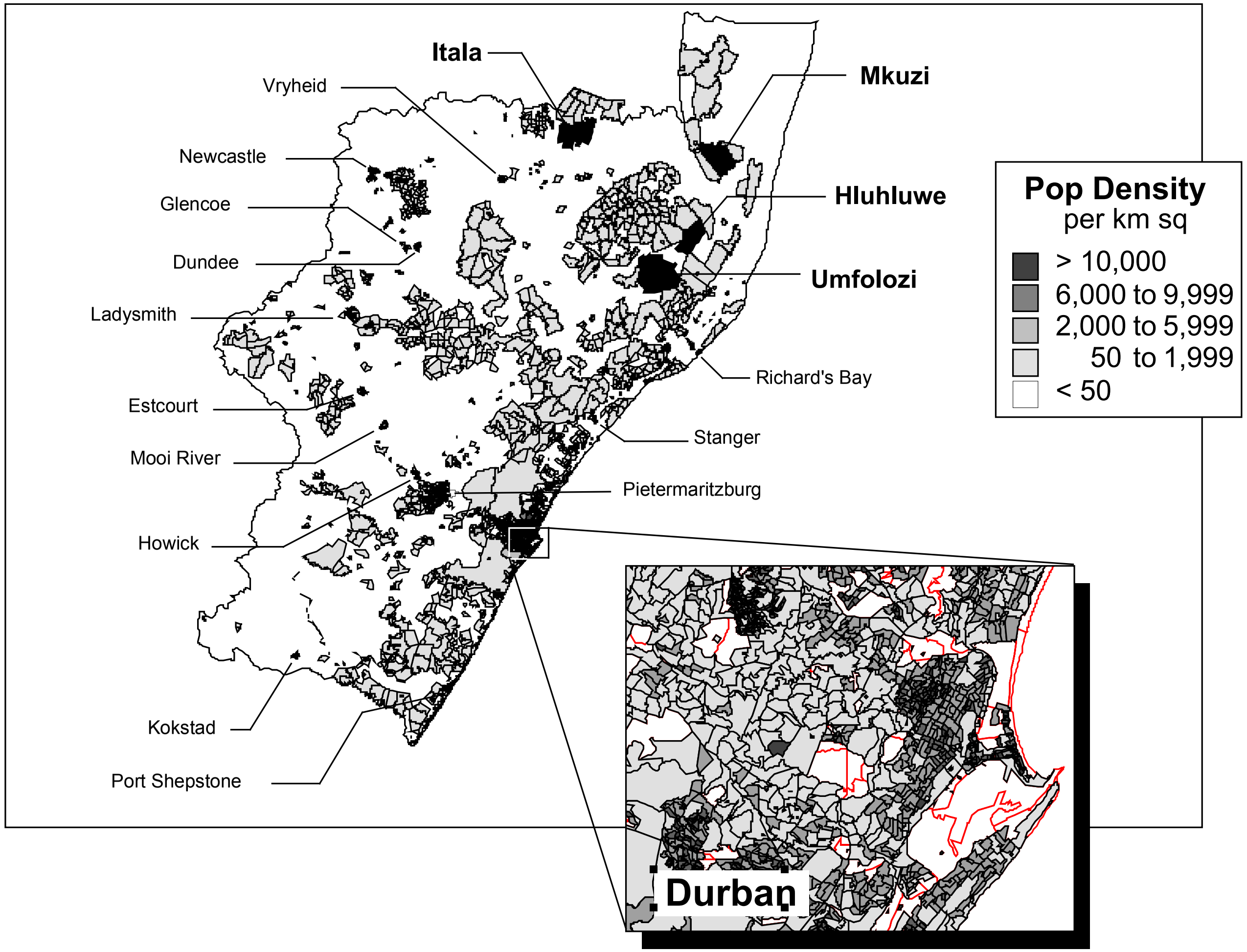
The KNPB's history of achievement in the field of conservation is second to none in Africa. The presence of the white rhino on the planet today is largely due to the efforts of the KNPB. Their intensive protection and relocation programme, centred on the Umfolozi game reserve, rescued these magnificent creatures from the brink of extinction. Nevertheless, the distinguished history of the KNPB has not sheltered them from the winds of change that have swept through South Africa in recent years.

The change of government in 1994 has been followed by a complete reassessment of the priorities placed on government spending. One of the areas of expenditure called into question has been the money provided for the provision of subsidised recreational facilities in KNPB reserves. Such facilities, especially those in the large game reserves, are used almost exclusively by South Africa's white population and by foreign tourists. Faced with increasing pressure to justify the money they receive from government the KNPB have shown an interest in being able to provide economic valuations of the recreational services they supply.

The study in this chapter concentrates on one of those recreational services, the provision of overnight accommodation in KwaZulu-Natal's four large game reserves; Hluhluwe, Umfolozi, Mkuzi and Itala. Consequently, the primary objective of the study is to provide an estimate of the value that the population of KwaZulu-Natal places on the provision of this recreational experience.



Map 1: South Africa and the Province of KwaZulu-Natal



Map 2: Population Centres of KwaZulu-Natal and the Four Game Reserves

2. Recreational Trips to the Game Reserves of KwaZulu-Natal

The four game reserves of KwaZulu-Natal are situated in the north-eastern region of the province (see Map 2). *Hluhluwe* and *Umfolozi* are amongst the oldest game reserves in Africa having been established at the end of the last century. Their central role in the conservation of the white rhino means that these parks comprise one of the last places on earth where these creatures can be seen in any abundance. Of the four reserves under study here, Hluhluwe and Umfolozi are the only two in which the so called "Big Five" (Elephants, Rhino, Lion, Leopard and Buffalo) coexist. Despite the fact that the two reserves are in close proximity, their climates and topographies differ markedly. *Hluhluwe Game Reserve* is characterised by rolling hills and wooded valleys. Being relatively high-lying it receives more rainfall than Umfolozi and the more abundant water supports a relatively large population of elephants. *Umfolozi Game Reserve*, on the other hand, is lower lying, dominated by the Black and White Mfolozi rivers that course through it. The vegetation varies from woodlands and thickets to undulating grassland and dry stretches of thornveld.

In contrast *Itala Game Reserve* is a relatively new reserve having been established from ranchland donated to the KNPB in the mid 1970's. The task of returning it to its natural state is now nearly complete and many of the larger species including rhino and elephant have been reintroduced, though as yet lion are not to be found at Itala. Like Hluhluwe, Itala is relatively high-lying but instead of rolling hills the reserve is characterised by granite boulder outcrops and deep narrow valleys.

Whilst rhino are a reasonably common sight in the fourth reserve, *Mkuzi Game Reserve*, neither elephant nor lion can be found in this reserve. Mkuzi contains a wide variety of habitats including grasslands, bush and riverine forests, though, in general, the reserve is more similar to Umfolozi in terms of topography and vegetation, than it is to either Hluhluwe or Itala. The diversity of habitats to be found in Mkuzi mean that it supports over 400 species of bird, compared to only 300 to be seen in Umfolozi and 320 recorded in Itala.

Clearly, the four reserves provide visitors with a similar though distinct recreational experience. In general, visitors come to enjoy the natural environment and to view the prolific wildlife, driving through the landscapes on the network of dirt roads that wander through the reserves.

As illustrated in Table 1, the concentrations of wildlife in the four reserves differ considerably. However, game viewing is by no means an exact science. It is quite possible to visit Hluhluwe Game Reserve for three days and never once see an elephant, despite this being the reserve with the highest concentration of these magnificent animals. Also, during much of the day many of the animals seek shelter from the heat of the sun. Resting in the shade of trees or hidden away in the bush, it becomes difficult to see wildlife for long periods of the day. Consequently, the best times for viewing game are in the cool hours just after sunrise and just before sunset when the wildlife is at its most active. Since it is forbidden to drive in the reserves after dark, the vast majority of visitors remain in the reserves overnight so that they can enjoy the wildlife spectacle at dusk and dawn.

Table 1: Approximate species concentrations in the KwaZulu-Natal game reserves

Species	Species Concentrations (Animals per 10 km^2)			
	Hluhluwe	**Umfolozi**	**Itala**	**Mkuzi**
Rhino	125	324	75	33
Elephant	34	7	10	-
Lion	6	10	-	-
Buffalo	476	933	8	-
Giraffe	47	25	67	44
Zebra	119	208	233	336
Wildebeest	70	250	400	437
Impala	480	1166	133	1761

To accommodate visitors, the KNPB provides a variety of facilities. Most of the accommodation is located in fenced camps dotted across the reserves, where visitors might also enjoy access to information centres and shops providing basic foodstuffs and equipment plus a variety souvenirs and curios. As well as these camps, the KNPB provide “bush camps”. Situated in isolated spots away from the fenced camps, visitors can hire out a bush camp exclusively for their own use. The accommodation in these bush camps is similar to that in the main camps though their isolation from other visitors results in a unique wilderness experience.

Table 2 provides a categorisation of the different types of accommodation that visitors can enjoy when visiting the reserves. Accommodation varies in its quality from a very basic hut containing just two beds but with access to communal ablution and cooking facilities, through to a luxury lodge with a living room, kitchen and ensuite bedrooms.

Table 2: Types of accommodation available in the game reserves

Reserve	Accommodation Type	Units	Bathroom	Kitchen	Tent	Living room	Electricity	Tariff (Rand)
Itala	*chalet*	*39*	✓	✓		✓	✓	*97*
	luxury lodge	*1*	✓	✓		✓	✓	*185*
	bush camp	*2*		✓		✓		*80*
	bush lodge	*1*	✓	✓		✓		*97*
Mkuzi	*basic hut*	*10*					✗/✓	*58*
	tent chalet	*8*	✓	✓	✓		✓	*67*
	bungalow	*9*	✓			✗/✓	✓	*74*
	cottage	*2*	✓			✓	✓	*80*
	bush camp	*2*	✓	✓	✗/✓	✓		*80*
Hluhluwe	*basic hut*	*20*					✓	*52*
	non-self catering	*20*	✓				✓	*86*
	chalet	*29*	✓	✓		✓	✓	*97*
	lodge	*1*	✓	✓		✓	✓	*185*
	bush lodge	*2*	✓	✓		✓		*97*
Umfolozi	*basic hut*	*18*					✓	*52*
	cottage	*2*	✓			✓	✓	*80*
	chalet	*6*	✓	✓		✓	✓	*74*
	lodge	*1*	✓	✓		✓	✓	*185*
	bush camp	*3*		✓	✗/✓	✓		*80*
	bush lodge	*1*	✓	✓		✓		*109*

Naturally, the higher the quality of accommodation the greater the nightly tariff charged by the KNPB (see Table 2). A basic hut can cost as little as R52 per person per night, whilst a luxury lodge costs R185 per person per night. Also, the different accommodation units have different numbers of beds. The KNPB has a minimum charge for each unit amounting to 75% of the amount they could charge if all the beds in that unit were being used. For example, a household of two, staying in a chalet with four beds, would have to pay the price for three individuals. One further point worth noting concerning the pricing regime is that pensioners and children under the age of 14 receive a discount, though this discount is not applicable to bush camps.

On top of accommodation charges the KNPB levies an entrance fee which is paid at the reserve gate. The entrance fee is R15 per car and R4 per adult. There is no daily charge independent of accommodation costs.

3. The Sample

Only a limited amount of accommodation is available in each of the reserves (see Table 2). To control visitor numbers, therefore, overnight accommodation must be reserved in advance. Visitors wishing to stay overnight in a reserve, phone through to the central office where each booking is logged onto a computer database.

The reservations database holds a great deal of information. It records the name, address and telephone numbers of all households reserving accommodation so that households can be subsequently billed. Details of the size of the party (the number of adults, juveniles and pensioners) is also recorded. Each unit of accommodation in every reserve is uniquely identified by a code and number. A household chooses which reserve they wish to visit, which type of accommodation they wish to stay in and how long they wish to stay, and are allocated a specific unit (or units) of accommodation. Thus, the KNPB can keep track of how many accommodation units are available in a reserve on any particular date. The database also records how much, in total, the visit cost each household.

Table 3: Number of trips taken to the reserves by households in the sample

Trips	No. of Households	Percentage
1	815	82%
2	135	13%
3	38	4%
4	9	1%
5	3	.03%
Total	1000	100%

The primary source of data for this study, therefore, consisted of a download from the KNPB's database containing details of some 25,827 bookings for visits to either Hluhluwe, Umfolozi, Itala or Mkuzi between 1st July 1994 and 31st June 1995. Computer routines were written to match separate bookings made by the same household and to identify households from the Province of KwaZulu-Natal. A random sample of 1000 households was identified and, where a household had made more than one visit to a game reserve in the period, one particular trip was selected. In general, the households took relatively few trips to the reserves over the course of the year. Indeed, 95% of the sample only visited the reserves once or twice over the course of the year (see Table 3).

Visits varied in length, with one household spending seven nights in a reserve, though the vast majority (97%) stayed between one and four nights.

Table 4: Lengths of time spent in the reserves by households in the sample

Trips Length (Nights)	No. of Households	Percentage
1	250	25%
2	451	45%
3	202	20%
4	71	7%
5	20	2%
6	5	.05%
7	1	.01%
Total	1000	100%

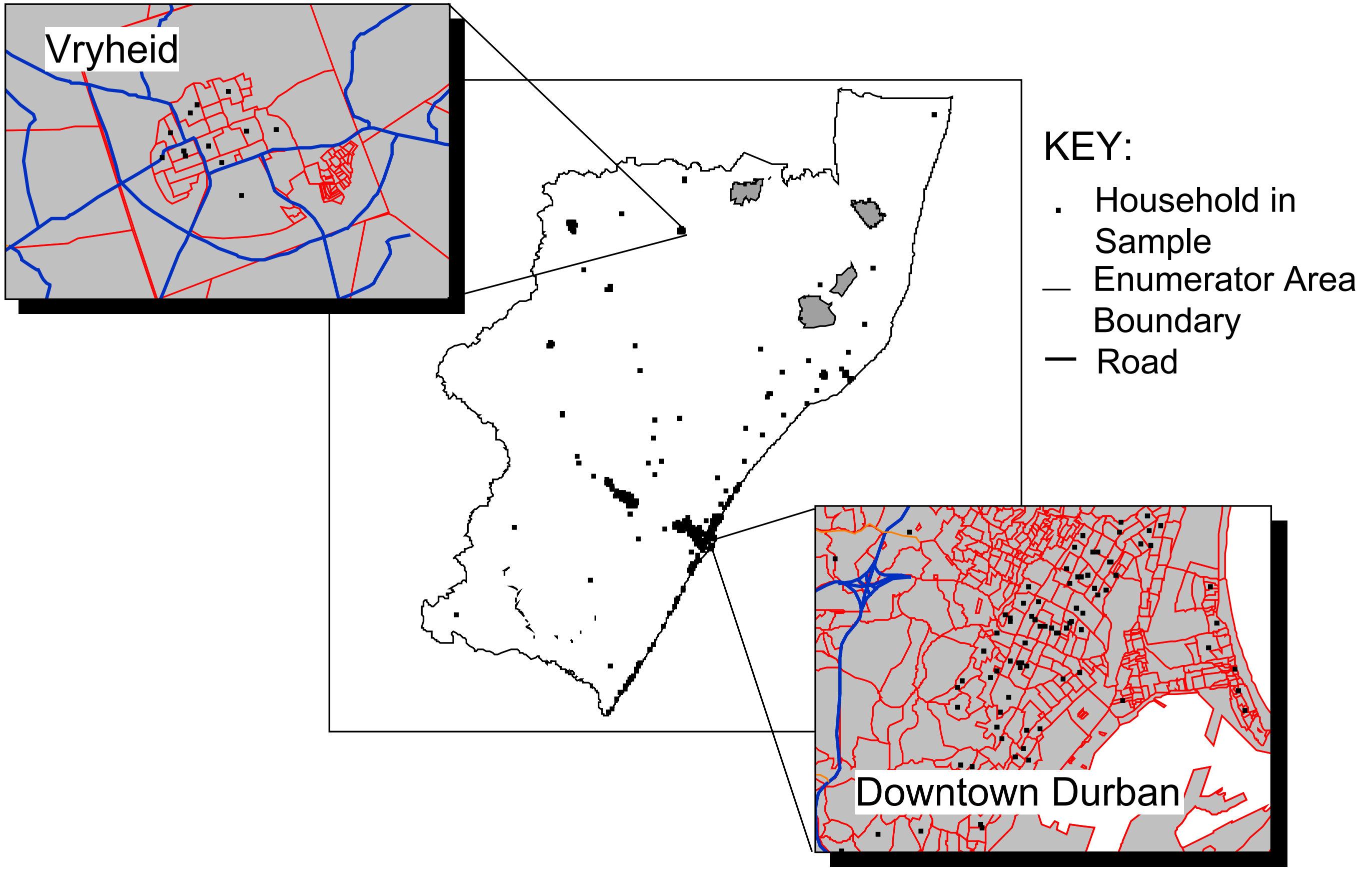
The origin of each of the households in the sample was determined from the address provided for billing in the KNPB reservations database. A Geographical Information Systems (GIS) was used to locate these addresses on an electronic map of KwaZulu-Natal. Map 3 plots out the home addresses of each of the visitors in the sample.

Table 5: Average distances travelled by visitors to the four game reserves

Reserve Visited	No. of Households in the Sample	Average One Way Distance Travelled by Visitors (km)			
		Total	A-Roads	B-Roads	Dirt Roads
Hluhluwe	411	241	198	27	16
Itala	182	338	90	244	4
Mkuzi	144	322	280	18	24
Umfolozi	263	243	206	32	5

The use of a GIS allowed the simple calculation of the distance travelled by each household. Indeed, the GIS allowed the precise calculation of door to reserve gate distances, distinguishing between distance travelled on A-roads, B-roads and dirt roads.

The GIS also allowed the gathering of approximate socio-economic details on each household. The Human Sciences Resource Council (HSRC) based in Durban, maintain data from the 1991 census. The smallest unit of the census is the ennumerator area, which on average comprised around 150 households. The HSRC possess GIS maps that define the boundaries of ennumerator areas and tie these in with socioeconomic data collected from that area in the 1991 census. Using the GIS, the address of each household was matched with its ennumerator area, allowing details of the socioeconomic characteristics of the household's neighbourhood to be collected.



Map 3: Location of visitors in the sample.

4. Recreational Demand Modelling

4.1. Continuous models of demand

Environmental resources are frequently the focus of recreational trips. Such trips come in all shapes and sizes. Many households take time out in the summer to spend a week or two enjoying the sunshine on a beach, or may travel off into the mountains to spend time skiing or hiking. More frequently households make use of environmental resources when they take a weekend drive out to the country to spend a day walking in woodland or visiting a nearby river or lake. Even everyday recreational breaks often make use of environmental resources, consider the throngs of office workers that pack out city parks at lunchtime.

Environmental economists have been interested in modelling demand for these recreational trips as a means of estimating the welfare value that people derive from having access to these natural resources. Unfortunately access to these natural resources frequently does not command a price, or if it does this price is often minimal and without sufficient variation to directly estimate a demand curve. Hence, conventional techniques of welfare estimation are frequently not applicable.

The solution to this problem was famously first forwarded by Hotelling. He noted that though the environmental resource is not itself a market good, the household in undertaking the recreational trip must also consume a number of complementary market goods. For short trips that last less than a day, this may amount to no more than the costs of travelling to the recreational site, for trips that involve staying overnight, the household will need to purchase other market goods such as lodgings.

Assuming that these goods exhibit *joint weak complementarity*, then a change in price that drove demand for the complementary market good to zero would at the same time drive demand for access to the environmental resource to zero. Put simply, if the price of accommodation at the site or travel to the site were too high then the household wouldn't visit the site at all. As neatly described by Hof and King (1992) the value of the resource can be determined by estimating a demand curve for any of these complementary goods and calculating the welfare value for the household by integrating between the present price faced by the household for the complementary good and the choke price. Thus the welfare value of the natural resource can be estimated by measuring a demand curve for any of the complementary goods needed to partake in the recreational experience.

Two basic models come out of this insight:

- First, and most well known, is the ***Travel Cost Model (TCM)***. As the name suggests, the model relies on the complementarity between travelling to the site and enjoying the recreational experience at the site. Demand for travel to the site, measured in number of trips per time period, is modelled as a function of the costs of travel incurred by the household in travelling to the site.
- Second is the ***On-site Cost Model (OCM)***. This model is only appropriate when households usually spend one or more nights at the recreational site. It relies on the complementarity between on-site expenditures, most notably for lodgings, and being able to spend time at the site enjoying the recreational experience. In this case demand for on-site experience, measured in number of days on-site, is modelled as a function of the daily on-site costs incurred by the household.

A number of problems preclude the use of these traditional demand models in the analysis of the KwaZulu-Natal game reserve data set:

i. On-site time in the TCM

The TCM implicitly assumes that each trip is being taken to consume the same recreational good. When households choose the amount of time they spend on-site, this is clearly not the case. Can we really say that a one day visit to a game reserve is the same good as a four day visit?

ii. Site Quality and Substitute Sites

In both models, it might be expected that the quality of the site will be an important determinant of the level of demand. Unfortunately, since datasets rarely exist in which changes in the qualities of a particular site are observed to vary, it is impossible to estimate their influence. Similarly, the price and qualities of other substitute sites will likely effect the level of demand for the recreational experience at one particular site. Again, neither the TCM nor the OCM easily provide for inclusion of these variables in the estimated demand function.

iii. Variation in Demand for Complementary Goods

From a purely practical point of view, to estimate either the TCM or the OCM, it is necessary to have considerable variation in the dependent variable (trips to the site and days on-site, respectively). Referring to Table 3, it is clear that households in KwaZulu-Natal tend to take only one or two trips to the game reserves in a year. With such little variation in the dependent variable, it would be impossible to estimate the TCM. Though there is somewhat more variation in the number of days spent on-site (see Table 4) it is still doubtful that there would be enough information in the data set to successfully estimate the OCM.

Clearly, the nature of demand for visits to the game reserves of KwaZulu-Natal does not easily lend itself to modelling in the traditional framework; households take very few trips in the year, they chose the number of days they stay on-site, they have the choice of visiting any one of four quality differentiated reserves and whilst at the reserve, they have the choice between an array of quality differentiated lodgings.

4.2. Discrete models of demand

In recent years, random utility models (RUMs) have become an increasingly popular approach to estimating the welfare benefits derived by visitors to recreational sites. Whilst the TCM and the OCM focus on *continuous decisions* (i.e. the choice of the *number* of trips a household undertakes in a year or the *number* of days stayed on any one visit, respectively) RUMs focus on the *discrete decision* between alternative recreational trips. Households are not seen as maximising utility by choosing the number of trips they intend to take in a year but by choosing the alternative which offers them the highest utility out of the options available to them on each separate choice occasion.

Modelling demand for the KwaZulu-Natal Game Reserves favours this latter approach, since the RUM is better able to model the decisions households make in choosing between a set of quality differentiated options. But what exactly are theses options? Researchers using RUMs have tended to concentrate on the choice between sites; explaining a visitor's decision by means of the different qualities of the available sites and the different costs of travelling to those sites. This is all well and good for 'day trips' but for recreational trips characterised by visits lasting a number of days, concentrating solely on the choice between sites may be a gross oversimplification. For such 'away-breaks', a visitor's choice of accommodation and length of stay may be just as important as the qualities of the site and the length of the journey in determining the costs and benefits that result from the trip. In effect, recreational trips like those taken to the KwaZulu-Natal game reserves are characterised by three dimensions of choice; the choice of which reserve to visit, the choice of how long to stay and the choice of which type of accommodation to stay in.

The literature, while abounding with examples of models demonstrating choices of the first type (i.e. between alternative recreational sites), provides details of few empirical applications that have addressed the second and third dimensions of choice (i.e. how long to stay and in what type of lodging). These other two dimensions of choice are especially pertinent for reserve managers attempting to maximise the revenues they receive from providing lodgings in a reserve. Clearly, increasing the entry fee for access to a reserve may not only result in visitors choosing to go to other reserves but quite as easily may result in them choosing to stay in less expensive accommodation or simply reducing the amount of time they spend on-site.

This paper describes the application of two RUMs (i.e. the logit model and the nested logit model) to the data taken from the KNPB's reservations database. Each record on the database is interpreted as the choice decision of an individual household. Having decided to take a trip to a game reserve, the household is faced with the three dimensions of choice described above (i.e. duration of stay, game reserve, accommodation type). Each particular combination of duration, game reserve and accommodation type represents a mutually exclusive alternative to the household. Together these options make up a finite set of alternatives from which the household must choose.

Let us denote each household by n (n = 1,2,...,N) and the set of alternatives a household faces by A_n. The choice set is subscripted by n to reflect the fact that the available options may possibly be different for different households making decisions at different times. For example, at the point in time at which a household decides to make a trip, accommodation of a certain type in a particular game reserve may be fully booked precluding it from their choice set.

The alternatives that the household face differ in their characteristics, for example each game reserve provides differing opportunities for viewing game and each accommodation type offers a different recreation experience whilst imposing a different cost on the household. The characteristics of alternative i as faced by household n is represented by the vector x_{in} for all i in A_n. Note that the characteristics associated with an alternative is subscripted by n since they may well vary across households. The costs of travelling to the different game reserves, for example, will be very different for a household travelling from Vryheid compared to those presented to a household travelling from Durban (see Map 2).

To add to this, different households faced with the same set of alternatives may well make different choices since they attach different values to the characteristics of the alternatives. Differences in valuation of the characteristics of the alternatives can be explained through the characteristics of the household. In the KwaZulu-Natal data set, for example, we might expect the number of pensioners in a household to increase their valuation of the quality of amenities provided by an accommodation type. Let us denote the vector of characteristics of household n as r_n.

Each option in the set of alternatives, A_n, available to a household would provide the household with a certain quantity of utility if chosen. From the point of view of the household the utility that results from choosing alternative i is determined by the relevant characteristics of the alternative x_{in} and its own characteristics r_n according to the indirect utility function;

$$U_{in} = U(x_{in}, r_n) \quad \text{for all } i \text{ in } A_n \qquad (1)$$

A utility maximising household will, presumably, choose the alternative which provides the highest utility. Hence, household *n* will choose alternative *i* if;

$$U(x_{in}, r_n) > U(x_{jn}, r_n) \quad \text{for all } i \text{ in } A_n \text{ where } j \neq i \qquad (2)$$

Clearly, from the point of view of the household the choice of option is determined simply by the relative utilities that they allot to the different alternatives. However, when we examine the same problem from the point of view of the researcher, the choice problem takes on a probabilistic aspect. In particular, researchers are unable to observe all the relevant factors influencing the household's decision. From their point of view the household's indirect utility function, $U(x_{in}, r_n)$, comprises two parts;

- The first part, consists of the utility that can be predicted from the characteristics of the alternatives (z_{in}) and those of the household (s_n) that are observable. This component can be described by the function $V(z_{in}, s_n, \beta)$ where β represents a vector of parameters to be estimated by the researcher. This is the observed portion of utility.
- The second component represents the utility derived from characteristics of the alternative and the household which are unobserved by. Let us denote this as ε_{in}.[1]

Hence the following equality can be formulated:

$$U(x_{in}, r_n) = V(z_{in}, s_n, \beta) + \varepsilon_{in} \qquad (3)$$

Since ε_{in} is unknown to the researcher it is impossible to predict the choice of the household with absolute certainty. Given an estimate of the observed portion of utility V_{in} associated with each available option, it is only possible to

[1] This component is sometimes also given a Random Utility interpretation (hence the name Random Utility Models). By this interpretation, ε_{in} is assumed to represent the part of utility which varies randomly across households rather than the effect of omitted variables though the two are functionally similar.

approximate the probability that a certain option would be chosen. We can write:

$$P_{\mathrm{in}} = \Pr\left(V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}\ [\text{for all } j \text{ in } A_n \text{ where } j \neq i]\right) \tag{4}$$

Where P_{in} represents the probability that the researcher will observe a household with a given known utility element (V_{in}) choosing alternative i. Rearranging (4) gives:

$$P_{\mathrm{in}} = \Pr\left(\varepsilon_{in} - \varepsilon_{jn} > V_{jn} - V_{in}\ [\text{for all } j \text{ in } A_n \text{ where } j \neq i]\right) \tag{5}$$

Given an estimate of the β vector of parameters, the researcher can calculate both V_{in} and V_{jn} and derive the difference $V_{in} - V_{jn}$ which makes up the right hand side of the inequality in (5). Meanwhile, the values of ε_{jn} and ε_{in}, which make up the left hand side of the inequality, are assumed to be drawn from some random distribution of possible values. Given this, the difference ε_{jn} - ε_{in} will also be a random variable. By assuming a specific distribution for the ε's the researcher is able to define the cumulative distribution of the random variable ε_{jn} - ε_{in}. This cumulative distribution provides the probability that ε_{jn} - ε_{in} will take on any particular value. With this information it is a simple step to obtain the probability that ε_{jn} - ε_{in} will take a value greater than the known value $V_{in} - V_{jn}$ for all j in A_n where $j \neq i$.

The total probability of observing the set of choices made by individuals in the sample, therefore, is given by;

$$L = \prod_{n=1}^{N} \prod_{i \in A_n} P_{in} \tag{6}$$

Maximum likelihood estimation techniques can be used to find the parameter vector β that results in the highest probability of observing individuals in the sample making their observed choices.

Specification of a random utility model thus involves two steps;

- first, it is necessary to specify the indirect utility function V_{in} so that estimates of the observed portion of utility for each option can be obtained.

- second an assumption must be made concerning the distribution of ε_{in}.

5. Specification of the Random Element in the RUM

Let us begin with the second of these steps. A common assumption made about the unobserved portion of utility is that each ε_{in} for all i in A_n is independently and identically distributed in accordance with the type I extreme value distribution.

$$f(\varepsilon) = \mu e^{-\mu(\varepsilon)} e^{-e^{\mu(\varepsilon)}} \tag{7}$$

Given such a distribution for the unobserved portion of utility, the function which relates the known portion of utility ($V_{in} = V(\mathrm{z}_{in},\mathrm{s}_n,\beta)$) to the probability that the household will choose alternative i is given by the multinomial logit model (MNL):

$$P_{in} = \frac{e^{V_{in}}}{\sum_{j \in A_n} e^{V_{jn}}} \tag{8}$$

The simple closed form of this expression means that the MNL model is generally preferred to other possible models resulting from different assumptions concerning the distribution of the random portion of utility (e.g. the probit model which assumes ε_{in} are distributed normally). However, the simplicity of the MNL model belies a fundamental difficulty with the model, its implicit restriction of independence of irrelevant alternatives (IIA). The IIA property of MNL models is simply illustrated by examining the ratio between the probabilities of two alternatives, i and k:

$$\begin{aligned} \frac{P_{in}}{P_{kn}} &= \frac{e^{V_{in}} \Big/ \sum_{j \in A_n} e^{V_{jn}}}{e^{V_{kn}} \Big/ \sum_{j \in A_n} e^{V_{jn}}} \\ &= \frac{e^{V_{in}}}{e^{V_{kn}}} \end{aligned} \tag{9}$$

Evidently the relationship between the probabilities of choosing *i* or *k* depends solely on the characteristics of those two alternatives. Changes in the characteristics of other alternatives or the changes in the availability of alternatives in the choice set, A_n, will have no influence on the ratio; the ratio is independent of "irrelevant" alternatives. This property is highly restrictive in so much as it denies the existence of patterns of substitution and complimentarity amongst options. For example, let us imagine that P_{in} in equation (9) represents the probability of staying in chalet type accommodation in Umfolozi game reserve whilst P_{kn} represents the probability of staying in a basic hut in Itala game reserve. Imagine that because of renovation work all the cottages in Umfolozi game reserve were no longer available to visitors. Since chalets offer a very similar type of accommodation to cottages, we would expect that the loss of the Umfolozi cottage option would result in a larger increase in the probability of a household choosing to stay in a chalet in Umfolozi (P_{in}) than in the probability that they would choose to stay in a hut in Itala (P_{kn}). Our expectations would suggest that the ratio of the two probabilities is not entirely independent of the other alternatives. Some options are clearly closer substitutes for each other than others and hence the use of a model that exhibits the IIA property is unlikely to be appropriate.

The problem of IIA is partially overcome by the extension of the logit model derived by McFadden (1978), commonly known as the nested multinomial logit model (NMNL). IIA assumes that all alternatives are equally dissimilar, so that no subset of alternatives can be considered more similar to each other than they are to the remaining alternatives. The NMNL overcomes the problem of IIA by explicitly grouping similar options.

To visualise such a system of alternatives, it is useful to represent the decision process as a "hierarchy of choices" defining the subsets within which IIA holds. A possible hierarchy of choices involved in the choice decision for a recreation experience in the KwaZulu-Natal game reserves is presented in Figure 1.

Figure 1 describes a system of nesting hypothesised by the researcher. It assumes that households regard all options which involve a short trip (defined as two days on site) as being more similar than options involving a long trip (four nights on site), and subsequently all accommodation types in a game reserve to be more similar than accommodation types in another reserve[2].

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[2] Other possible nesting structures have been investigated by the author but the results of this research are not presented here.

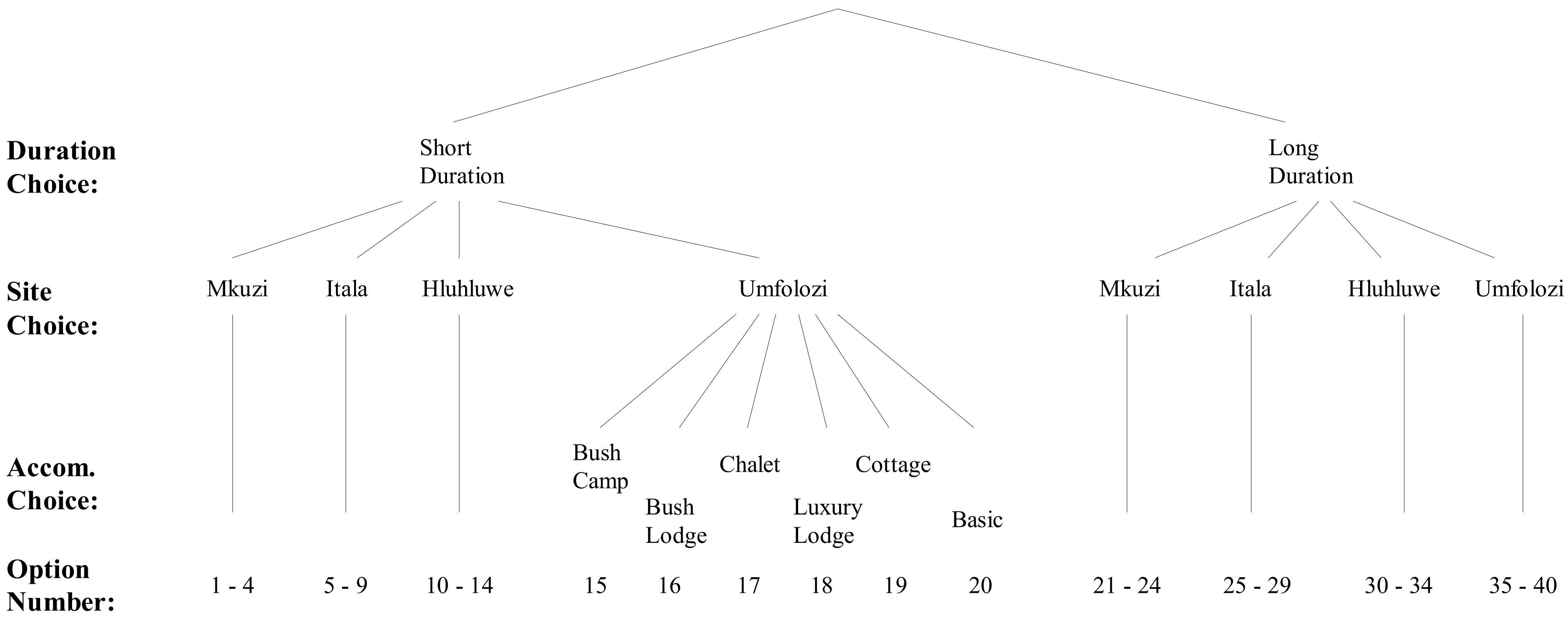

Figure 1: Hypothesised nesting structure for recreational trip options open to visitors to the KwaZulu-Natal game reserves (only the Umfolozi, short duration branch is exploded to show accommodation choices).

More formally, this hierarchy divides the set of all options A_n into two clusters based on whether they involve a long or short duration trip. Let us denote the set of top level clusters as C_n^r , where r indexes each duration group. At the second level, the top level clusters are further grouped into options which involve staying in the same game reserve. The set of second level nests will be denoted B_n^{lr}, where l indexes each game reserve grouping for a particular duration of visit, r.

McFadden (1981) has shown how such a pattern of nesting can be derived within a random utility maximising framework by assuming that ε_{in} for all i in A_n are drawn from a generalised extreme value (GEV) distribution with a joint CDF given by;

$$F(\varepsilon_1, \varepsilon_2, ..., \varepsilon_I) = \exp\left(-\sum_r (\sum_{l \in C_n^r} (\sum_{i \in B_n^{lr}} e^{\varepsilon_{in} / \delta_r \lambda_{lr}})^{\lambda_{lr}})^{\delta_r} \right) \tag{10}$$

Given this distribution for the ε_{in} it can be shown that the probability of choosing alternative i is

$$P_{in} = \frac{e^{V_{in} / \delta_r \lambda_{lr}} (\sum_{j \in B_n^{lr}} e^{V_{jn} / \delta_r \lambda_{lr}})^{\lambda_{lr} - 1} [\sum_{l \in C_n^r} (\sum_{j \in B_n^{mr}} e^{V_{jn} / \delta_r \lambda_{mr}})^{\lambda_{mr}}]^{\delta_r - 1}}{\sum_s (\sum_{m \in C_n^s} (\sum_{j \in B_n^{ms}} e^{V_{jn} / \delta_s \lambda_{ms}})^{\lambda_{ms}})^{\delta_s}} \tag{11}$$

The NMNL model given by equation 11 assumes that the marginal distribution of each ε_{in} still follows the univariate extreme value distribution that results in the simple logit model described above. In the example laid out in figure 2., this is tantamount to saying that the IIA assumption still holds across subsets. That is, if we were to eliminate all of the accommodation types available in one reserve, we would expect the relative probabilities of choosing the other reserve-accommodation alternatives not to change.

However, the GEV also allows for the fact that all ε_{in} within a subset are correlated. The new parameter λ_{lr} and δ_r are known as scale parameters or dissimilarity parameters. λ_{lr} is a measure of the correlation of unobserved utility within the set of options in B_n^{lr} and δ_r is a coefficient estimated to measure the correlation within the set of options in C_n^r.[3] If λ_{lr} and δ_r are set equal to one (indicating no correlation in unobserved utility within subsets) then the expression reduces to the simple multinomial logit model of equation 8.

[3] More correctly 1 - λ_{lr} measures the correlation within a subset of options in a particular reserve for a particular duration, as λ_{lr} itself drops as the correlation rises. Likewise 1 - δ_r measures the correlation within a subset options of a certain duration since δ_r falls as correlation between these options rises.

6. Specification of the Indirect Utility Function in the RUM

For simplicity the indirect utility function, $V_{in}(\cdot)$, is given the simple linear form $\boldsymbol{X\beta}$, where $\boldsymbol{X}$ is the vector of variables describing the qualities of the different options and $\boldsymbol{\beta}$ is a set of parameters to be estimated by the RUM. In general we would expect three major groups of variables to influence household's choice between options;

- The characteristics of the household (s_n in the previous terminology)
- The characteristics of the different options (z_{in}), and
- The costs of the different options

6.1. Characteristics of the households

As described previously, the characteristics of the households were derived from information contained in the KNPB database (e.g. whether the household contained pensioners or juveniles) and from the GIS data set for the enumerator area in which the household lived (e.g. average household income in that neighbourhood). However, whilst we might well expect household characteristics to influence their choice of option, the inclusion of such variables in the specification of the indirect utility function is somewhat complicated. This complexity derives from the fact that for each household, there is no variation in the household characteristics between the options; there will be the same number of juveniles in the household no matter which option they choose. The simple inclusion of household characteristics in the specification of $V_{in}(\cdot)$ for each option i, therefore, cannot influence the relative probabilities (P_{in}) of choosing the different options. To overcome this problem, researchers tend to interact the characteristics of the households with characteristics of the options. In this piece of work, two such variables were constructed;

- A dummy variable that defined households with juveniles and pensioners was interacted with a dummy variable distinguishing bush camps from other types of accommodation. This variable was included to reflect the fact that households with juveniles and pensioners may be less keen to stay away from the facilities provided in the main camps and also that juveniles and pensioners do not receive discounts for bush camp accommodation.
- A household income variable specific to options of long duration. This variable was included to investigate the possibility that those households with higher income may be more likely to stay longer on site.

6.2. Characteristics of the options

In this model the household is faced by three distinct aspects of choice, the duration of the visit, the reserve that is visited and the type of accommodation in which to stay.

6.2.i Choice of Accommodation

The utility offered by a particular type of accommodation will be determined by the facilities provided by that accommodation. Accommodation within the parks is provided in a number of different ‘camps’. These can be ‘main camps’ where up to 69 units of accommodation are gathered in a fenced enclosure. Main camps provide communal ablution and cooking facilities for those accommodation units that do not possess their own bathrooms or kitchens. The larger camps may also provide other facilities such as a shop, swimming pool or restaurant. The second type of camp available to tourists are ‘bush camps’. These are set in remote locations in the reserve where a household can exclusively hire out the camp to assure total privacy away from the normal tourist camps. It could be argued that the choice of camp could provide another dimension of nesting in the model but this has been avoided to maintain simplicity. In the final model three variables have been included to define the characteristics of the camps;

- a dummy variable for whether the camp has a shop,
- a dummy variable for bush camps, and8
- a dummy variable for households with juveniles or pensioners specific to bush camp options (discussed above).

If patterns of correlation exist between options that involve staying in bush camps then including a constant specific to these options goes some way to ensuring that the IIA property still holds (see Train 1986, p 23).

The indirect utility function was also specified to reflect the qualities of the actual accommodation. Three variables were included in the final model;

- a dummy variable for accommodation that had its own bathroom,
- a dummy variable for accommodation that included its own kitchen and
- a dummy variable for those accommodation units that were constructed from canvas tenting (a number of the bush camps as well as some of the lodgings in Mkuzi are effectively tents, allbeit rather luxurious tents containing wooden floors and proper beds).

In addition, a variable was included for each option that described the minimum cost number of units of that type of accommodation that could accommodate the household (the calculation of this variable is discussed in greater detail below). This variable was included under the assumption that households would prefer to stay together in one accommodation unit rather than be split across a number of different units.

6.2.ii Choice of Reserve

Households have the choice between four different reserves, Umfolozi, Hluhluwe, Mkuzi or Itala. It was assumed that visitors chose between the different reserves based on the quality of the game-viewing experience. The small number of different sites used in the study[4] limited the degree to which the sites could be characterised. With four sites it is possible to specify a maximum of three site specific quality variables. Though a number of specifications were attempted that included different species densities in each reserve, it was decided that no three species could adequately describe the game-viewing experience. Instead, a simpler approach was adopted; specifying a dummy variable for each of the reserves. Whilst giving little insight into which characteristics of the reserves are important in determining household choice, this formulation provides a measure of the relative preferences for each of the four reserves. Taking Mkuzi as the base case the sign and size of the parameter estimated on the dummy variables for each of Hluhluwe, Itala and Umfolozi reflect the samples relative preferences.

The choice between travelling to one reserve rather than another may also be influenced by qualities of the trip. The specification of representative utility therefore includes a variable for the number of kilometres that must be travelled on dirt roads.

6.2.iii Duration of Visit

Unlike most applications of recreational demand modelling, the model developed here allows for the different utility that households derive from trips of different lengths. Most previous applications have assumed that all visits to a particular site are of a constant length. Morey et al. (1993) in a model of demand for Atlantic salmon fishing, for example, assumed that trips undertaken by anglers to rivers in Maine were all of two days duration whilst those to Canadian rivers were all of four days duration. Some empirical evidence

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[4] As compared to the water-based recreation studies in the U.S. where researchers often model the choice between a hundred or more sites (e.g. Hausman et al., 1995; Feather et al., 1995).

appears in the literature to suggest that duration of stay may be an important dimension of choice for recreationists. Gibbs (1974), Green (1986) and more recently Bell and Leeworthy (1990), for example, have all reported empirical applications that demonstrate a positive relationship between travel costs and time on site. This may indicate that households may compensate for investing more time and expenditure travelling to a site by increasing their time on site.

The model presented here includes four variables that are thought to influence the choice between short and long duration visits.

- A variable for distance travelled specific to taking a long duration trip. Such a variable will have a positively signed coefficient if households that travel longer distances are more likely to stay longer on site.
- A dummy variable for trips taken during holiday periods specific to long duration trips is included to reflect the assumption that households are more likely to take longer trips during these periods.
- Household income is also included as a long duration trip specific variable under the assumption that households with higher incomes are more likely to choose trips of a longer length than households on lower incomes.

Finally, a long duration specific variable is included. As it is assumed that the longer a household stays on site the more utility they receive from a trip, a priori expectations are that this constant will have a positive coefficient.

6.3. The costs of travel and accommodation

Clearly, the relative costs of the different options will be an important factor in determining household decisions. Obviously, the costs of accommodation and travel will be considered by the household. Table 6 provides average costs for accommodation and travel and shows how these vary for those taking long trips and those taking short trips. It is interesting to note that for short as well as long trips the cost of accommodation considerably outweighs the cost of travel. Notice also that those opting for long duration trips (i.e. trips lasting three days or greater) tend to have incurred greater travel costs than those opting for shorter trips. As discussed above, this may indicate that households compensate themselves for investing more time and expenditure travelling to a site by increasing their time on site.

Table 6: Average costs of travel and accommodation for trips of different durations

Duration	Trips	Cost
Short	Travel	$14
	Accommodation	$110
	Total	$124
Long	Travel	$17
	Accommodation	$216
	Total	$233
Overall	Travel	$15
	Accommodation	$142
	Total	$157

The costs of travelling to the different reserves for each household were calculated with the aid of GIS techniques. The use of GIS allowed exact door to gate road distances to be calculated for each household and for this distance to be decomposed according to the type of road. Using a figure of R1.50 per litre of petrol, costs of travel were calculated assuming that travelling on;

- major roads would allow an average speed of 90 km/h (60 mph), achieved with a petrol consumption rate of 6 litres per 100km[5]
- minor roads would allow an average speed of 70 km/h (45 mph), achieved with a petrol consumption rate of 7 litres per 100km
- dirt roads or in towns would allow an average speed of 65 km/h (40 mph), achieved with a petrol consumption rate of 8 litres per 100km

Some researchers (e.g. Morey, 1981) include an element in the travel costs designed to reflect the standing charges of running a car (e.g. maintenance, road tax, insurance). In this study only the operating charges of the journey are included reflecting the assumption that only costs perceived to be directly

[5]Petrol consumption rates are taken from estimates given by Ford for an average 4-door family saloon.

incurred in the taking of the trip will be considered by households in choosing between options.

The database held information on the cost of the accommodation actually chosen by the household but for other accommodation types, in different reserves and of different durations, costs were calculated using an algorithm written by the author. This algorithm involved ascertaining which specific units of accommodation had not already been booked by another party at the time when that household had made their booking. Each accommodation booking in the database is identified by a unique reference number that is allocated sequentially by the KNPB's reservations system. Therefore, an accommodation unit that had been booked with a reference number lower than that allocated to the household under consideration could not have been available to them when they were making their choice of accommodation. The algorithm identified all units of a specific accommodation type that were available to a household in a single camp in a given reserve for a given duration. As there could be some variation in the costs of these units and in many cases the household was sufficiently large that it would require more than one unit to accommodate all members of the party, the algorithm calculated the least cost combination of units to accommodate that party. The number of units required to accommodate the household in a particular type of accommodation was included as an explanatory variable under the assumption that a household would prefer to stay in accommodation that housed them as one group rather than splitting them into a number of groups.

The calculation of minimum costs for a particular type of accommodation took account of discounts given for pensioners and juveniles at certain times of year in certain types of accommodation and minimum charges placed on the rental of all units. The final accommodation cost variables, therefore, reflected almost exactly the costs of the alternative options that the household would have faced when making their decision.

6.4. The costs of time travelling and time on-site

Time is a scarce resource to the household. Since the time the household spends undertaking a recreational trip could be spent in some other activity that could confer utility, the household incurs an opportunity cost. Hence, the cost of time spent in travel and on-site, as well as the cost of travel and accommodation, should be included in the recreational demand model. To understand better how we might derive a specification of the indirect utility function that combines these elements of the full cost of the trip, it is instructive to look at a model of household consumption decisions. The model presented here is essentially that of De Serpa (1971), though some minor additions have been included.

De Serpa's main contribution to the understanding of household consumption decisions was the inclusion of time directly in the utility function. The inclusion of the time variables in the utility function reflects the assumption that time *per se* may yield utility or disutility to the household. De Serpa presents the household utility function as[6];

$$U(x_1, x_2, \ldots, x_n, t_1, t_2, \ldots, t_n, t_w) \quad (12)$$

where x_i is the quantity of commodity i consumed by the household,

t_i is the time spent in the consumption of x_i units of the i^{th} commodity and

t_w is time spent working.

For the purposes of this analysis we can envisage the household consuming quantities of two goods (x_1 and x_2) which require time (t_1 and t_2) spent in very different circumstances:

- x_1 is the number of trips the household decides to take to a recreation-site. Each unit consists of the bundle of market goods that must be purchased by the household to take one trip to the recreation-site. In the case of the KwaZulu-Natal game reserves, this bundle amounts to the purchase of enough petrol to make the round trip to the game reserve.
- x_2 is the number of units of on-site recreational experience that the household decides to purchase. In this case, units of on-site recreational experience are measured in days. Each unit of x_2 consists of the bundle of market goods that must be purchased by the household in order to spend one day enjoying the recreational opportunities available at the site. At a minimum we would imagine this bundle to include entrance tickets plus the purchase of on-site accommodation.
- t_1 is the amount of time that the household decides to spend undertaking the x_1 number of trips to and from the recreation-site.
- t_2 is the amount of time that the household chooses to spend enjoying the x_2 units of on-site recreational experience. In other words, having purchased the required entrance tickets and nights of accommodation to spend x_2 days at the reserve, the household can freely choose the number of hours they wish to spend enjoying the on-site recreational experience.

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[6] As in De Serpa (1971) it is assumed that all goods and time and are consumed in positive quantities. Also for ease of exposition the qualities of the various goods are suppressed.

As De Serpa points out, the amount of time allocated to the consumption of any good is partly through necessity - it takes a minimum amount of time to consume that good, and partly a matter of choice - one can take one's time consuming a good if it is an enjoyable experience or can get it out the way as quickly as possible if it is not. Thus for each unit of the i^{th} good, a household must allocate at least a bare minimum amount of time to its consumption. Following De Serpa's notation let us call this minimum amount of time a_i.

For a certain class of goods which have explicit in their purchase a time dimension, there may also be a maximum amount of time that a household can spend consuming each unit of the good. In the case of time on-site in the recreational demand model, each unit of x_2 entitles the household to spend up to one day's recreational activity at the site. If they wish to spend longer at the site they would have to purchase another unit of on-site time. Let us label this quantity of time b_i, such that for the i^{th}, the following inequality must hold;

$$b_i x_i \geq t_i \geq a_i x_i \qquad (13)$$

In the recreational demand model;

- a_1 is the minimum amount of time it would take a household to travel to the recreation-site and equation (12) ensures that the household makes a trip of at least this minimum length of time. Note that for travelling, there is no upper time constraint, b_1; within reason, the household can travel as slowly as they like whilst driving to the game reserve.
- b_2 is the maximum amount of time the household can spend enjoying the recreational experience at the site for each unit of x_2 purchased. The household can spend all of each day they are at the site enjoying the recreational experience, at the other extreme they could pay their entrance fee and turn around and leave straight away. Indeed, for time at a recreational site, we might expect a_2 to take a value of zero.

The household will seek to maximise their utility function (12) subject to equation (13), their budget constraint;

$$wt_w = \sum_{i=1}^{n} p_i x_i \qquad (14)$$

where $p_i \geq 0$ is the price of the i^{th} consumption good,

w is the hourly wage rate,

t_w is the time at work,

and their time constraint;

$$T = t_w + \sum_{i=1}^{n} t_i \tag{15}$$

Where T is the total amount of time available in the decision period.

The problem then is to maximise the Lagrange function;

$$\begin{aligned} L = U(x_1, x_2, ..., x_n, t_1, t_2, ..., t_n, t_w) + \lambda(wt_w - \sum_{i=1}^{n} p_i x_i) + \mu(T - t_w - \sum_{i=1}^{n} t_i) \\ + \sum_{i=1}^{n} \gamma_i (t_i - a_i x_i) + \sum_{i=1}^{n} \eta_i (b_i x_i - t_i) \end{aligned} \tag{16}$$

Where λ is the Lagrange multiplier on the budget constraint and represents the utility that would arise from a marginal increase in the households income

μ is the Lagrange multiplier on the time constraint and represents the utility that would arise from a marginal increase in the amount of time that were available to the household

γ_i is the Lagrange multiplier on the minimum time allotment for the consumption of a unit of the i^{th} good, and represents the utility that would arise if the household could save a unit of time consuming that good.

η_i is the Lagrange multiplier on the maximum time allotment for the consumption of a unit of the i^{th} good, and represents the utility that would arise if the household were allowed to spend an extra unit of time consuming that good.

Which gives rise to the first order conditions:

$$U_{x_i} = \lambda p_i + \gamma_i a_i - \eta_i b_i \tag{17}$$

$$U_{t_i} = \mu - \gamma_i + \eta_i \tag{18}$$

$$U_{t_w} = \mu - \lambda w \quad (19)$$

$$\gamma_i(t_i - a_i x_i) = 0 \quad (20)$$

$$\eta_i(b_i x_i - t_i) = 0 \quad (21)$$

For the purposes of estimating recreational demand models a number of interesting results arise from De Serpa's model.

6.4.i The price of time

The Lagrange multiplier μ is a measure of the marginal utility of time, whilst λ is a measure of the marginal utility of income. The ratio μ/λ, therefore, gives a measure of the marginal value of time. Taking the FOC given in equation (19) of the De Serpa model, therefore, and dividing through by the marginal utility of income reveals the marginal value of time to be;

$$\frac{\mu}{\lambda} = w + \frac{U_{t_w}}{\lambda} \quad (22)$$

The marginal value of time is the difference between the wage rate and the value of the (dis)utility of an extra hour spent working. This result was pointed out by Cesario (1976). Assuming that an extra hour of work represents a disutility then the value of time will be less than the wage rate[7].

6.4.ii The price of travel

Let us assume now that households travel to the recreational site in the minimum time possible. In other words, the right hand side of equation (13) holds as the equality $t_1 = a_1 x_1$. Clearly, with this assumption the bracketed expression in the Khun-Tucker condition given in equation (20), will evaluate to zero. For the condition to hold, therefore, the Lagrange multiplier γ_1, can take any value.

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[7] Note, that this is a very simple model, when households face institutional restrictions such that they cannot trade off between time in work and time at leisure then the wage rate cannot be considered the correct measure. In this latter case the marginal value of time will depend not only on the wage rate but also on a number of other factors relating to the household's time allocation problem (Smith et al. 1983).

Conversely, there is no maximum amount of time that the household can spend travelling to the site. We assume that the left hand side of equation (13) holds as the inequality $t_1 < b_1 x_1$. With this assumption the bracketed expression in the Khun-Tucker condition given in equation (21), will not evalute to zero. For the condition to hold, therefore, the Lagrange multiplier η_1 must take a value of zero.

The condition given in (17) is the classic marginal condition. At their utility maximising consumption bundle, the household will equate the utility from the consumption of an extra unit of each good, with the marginal disutility of expenditure in money and time on that extra unit. For travel to a recreational site we have already established that η_1 takes a value of zero, such that rearranging (18) and dividing through by the marginal utility of income gives;

$$\frac{U_{x_1}}{\lambda} = p_1 + \frac{\gamma_1}{\lambda} a_1 \qquad (23)$$

The right hand side of equation (23) represents the marginal cost of a trip to a game reserve. It is made up of two components the price of the trip, p_1, (i.e. the expenditure on petrol needed to travel to and from the recreational site) and the cost of time travelling, $a_1 \gamma_1 / \lambda$, where γ_1 / λ represents the price of each unit of time spent travelling.

We can get a clear understanding of what this last expression represents, by rearranging equation (18) and dividing through by λ. Again the term containing η_1 falls out and we are left with;

$$\frac{\gamma_1}{\lambda} = \frac{\mu}{\lambda} - \frac{U_{t_1}}{\lambda} \qquad (24)$$

Each unit of time spent travelling is valued at the marginal value of time, minus the value of the marginal (dis)utility of travelling. If we assume that travelling represents a disutility then U_{t_1}/λ is negative and the price of time travelling will be greater than the price of time in general. A household is willing to pay more to avoid an hour spent in travel because the time spent travelling is not utility raising. As De Serpa points out, γ_i / λ is in effect the value of saving time in consuming the i^{th} good. If a household can save time in the consumption of a particular good then this time can be transferred to the consumption of another good that provides them with greater value.

Replacing (24) in (23) gives the following result;

$$\frac{U_{x_1}}{\lambda} = p_1 + \left(\frac{\mu}{\lambda} - \frac{U_{t_1}}{\lambda}\right)a_1 \tag{25}$$

The price considered by household in taking a trip is a combination of the travel expenses and the value of time saved.

6.4.iii The price of the on-site experience

Analysis of the price of the on-site experience follows much the same logic as that just outlined for the price of trips to the recreation-site. With on-site time, however, we assume that households spend at least some time enjoying the recreational experience at the site for each day that they visit. Since a_2 must equal zero (there is no lower limit to the amount of time that a household could spend in recreational activities at the site) the right hand side of equation (13) holds as the inequality $t_2 > a_2x_2$. From (20) the Lagrange multiplier γ_2 must, therefore, equal zero and, as we might expect, the model predicts that the household allots no value to saving time in recreation.

On the other hand, we assume that the household chooses to spend the maximum amount of time it has available each day to enjoying the recreational site (b_2). In this case the left hand side of equation (13) holds as the equality $t_2 = b_2x_2$ and, from (21), the Langrange multiplier η_2 can take any value.

Turning once again to the marginal condition in (17), we find;

$$\frac{U_{x_2}}{\lambda} = p_2 - \frac{\eta_2}{\lambda}b_2 \tag{26}$$

Again we can solve for η_2 from (18) and replace this in (26) which gives;

$$\frac{U_{x2}}{\lambda} = p_2 + \left(\frac{\mu}{\lambda} - \frac{U_{t_2}}{\lambda}\right)b_2 \tag{27}$$

The marginal cost to the household of a day on-site consists of the price of the bundle of goods that must be consumed to spend that extra day on-site (p_2) and the marginal value of time spent in on-site recreation. Since we assume that the utility of an extra hour on-site per day is at least non-negative, the household values this time at less than the opportunity cost of time in general.

A number of conclusions can be drawn from this analysis;

1. From (22), the marginal value of time in general is some portion of the wage rate.
2. From (25), the marginal value of time spent travelling is greater than the marginal value of time in general.
3. From (27), the marginal value of time spent on-site is less than the marginal value of time in general.

Of course, the marginal values of time presented in equations (21), (24) and (26) are those that are defined for the continuous utility maximising problem in which the household chooses a bundle of goods to consume and allots time to their consumption. However, as shown by Hanemann (1984) the discrete choice problem described in the previous section is a special case of this problem. In modelling a discrete choice, it is assumed that the household is at a corner solution in so far as they can only choose one trip which they must allocate to one of the different recreational sites. Though this added restriction may change the absolute values of time that result from the model, we would not expect that the relative values placed on the different uses of time would change; we would still expect the value of time travelling to be lower than the general value of time since extra travelling is likely to represent a disutility to the household and, in the same vein, we would expect the value of time on-site to be less than the general value of time since extra time on-site is likely to be utility raising for the household.

The question still remains as to how to include the costs of travel, accommodation, time travelling and time on-site in the specification of the indirect utility function. One possibility would be to include them independently, i.e.

$$V_{in} = \beta_1 tc_{in} + \beta_2 oc_{in} + \beta_3 tt_{in} + \beta_4 ot_{in} + \ldots + \varepsilon_{in} \tag{28}$$

where tc_{in} is the travel cost incurred in travelling to the recreational site of the i^{th} option,

oc_{in} is the lodging costs incurred by the household in staying in the particular accommodation type for the number of days defined by the i^{th} option,

tt_{in} is the travel time taken by the household to travel to the recreational site of the i^{th} option,

ot_{in} is the time spent on-site by the household as defined by the i^{th} option,

β_1, *and* β_2 are parameters to be estimated on the cost variables, and represent estimates of the marginal disutility of expenditure, and

β_3, and β_4 are parameters to be estimated on the time variables, and represent estimates of the marginal (dis)utility of time spent travelling and recreating respectively.

However, a problem with colinearity arises if all four variables are included independently in the indirect utility function. Specifically, the costs of travel (tc_{in}) and time spent travelling (tt_{in}) are nearly always colinear (the further the household has to travel the more it must spend on petrol) whilst the cost of on-site lodgings (oc_{in}) will be colinear with time spent on-site (ot_{in}) (the longer a household stays on-site the more it will cost them in accommodation charges).

Clearly, it would be impossible to empirically estimate parameters on all four variables. In the past, researchers have tended to overcome this problem by monetarising the cost of time spent travelling using some exogenously determined price of time, and then combining the cost of travel with the time cost in one total cost variable (e.g. Morey, Rowe and Watson, 1993, Kaoru, Smith and Liu, 1995). Following empirical evidence presented by Cesario (1976) the most common assumption is that the price of time spent travelling can be valued at between ¼ and ½ of the wage rate. At the same time most previous applications have simply ignored on-site costs and thus have not dealt with the issue raised by the De Serpa model that time spent on-site will have a different value to time spent travelling.

However, when the monetary costs of a trip include both travel and on-site expenses, it is possible to directly estimate the prices of time in the two different activities. To do this, we first make the observation that the marginal disutility of expenditure is simply the negative of the marginal utility of income; at the margin an extra unit of cost will decrease utility by the same amount as an extra unit of income would increase utility[8]. Given this, we assume that $\beta_1 = \beta_2 = -\lambda$.

Further, from the De Serpa model we assume that the cost of time travelling and the cost of time on-site can be monetarised as some unknown proportion of

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[8] Indeed, a number of researchers have specified the cost variable in the indirect utility function as income minus costs, though this makes no difference to the absolute value of the parameter estimated.

the wage rate that we wish to estimate. This follows from equations (25) and (27) where the marginal value of time in the two activities (travelling and recreating) is given as the terms in brackets. Substituting in (25) for the expression for the general value of time given in equation (22), reveals that the marginal value of time travelling is given by;

$$w - \frac{U_{t_w}}{\lambda} - \frac{U_{t_1}}{\lambda} = \alpha_1 w \qquad (29)$$

where $\alpha_1 = 1 - \frac{U_{t_w}/\lambda - U_{t_1}/\lambda}{w}$ and is a parameter that we wish to estimate that gives the proportion of the wage rate that represents the value of time travelling. Further we assume that α_1 is constant across all households.

Following the same logic, substituting (22) in the value for on-site time given in (27) gives;

$$w - \frac{U_{t_w}}{\lambda} - \frac{U_{t_2}}{\lambda} = \alpha_2 w \qquad (30)$$

where $\alpha_2 = 1 - \frac{U_{t_w}/\lambda - U_{t_2}/\lambda}{w}$ and is a parameter we wish to estimate that gives the proportion of the wage rate that represents the value of time spent on-site. Again we assume that α_2 is constant across all households.

Since $\alpha_1 w$ and $\alpha_2 w$ are the prices for time in the two activities, we can use these expressions to convert the time variables in the indirect utility function into monetary costs. Hence, we can rewrite (29) as;

$$V_{in} = \beta_1 \left(tc_{in} + oc_{in} + \alpha_1 . w_n . tt_{in} + \alpha_2 . w_n . ot_{in} \right) + \ldots + \varepsilon_{in} \qquad (31)$$

For the purposes of estimation it is far easier to use;

$$V_{in} = \beta_1 \left(tc_{in} + oc_{in} \right) + \beta_3 w_n . tt_{in} + \beta_4 w_n . ot_{in} + \ldots + \varepsilon_{in} \qquad (32)$$

Then an estimate of α_1 is given by β_3/β_1 and an estimate of α_2 can be recovered from β_4/β_1. The specification of the indirect utility function in the model presented here, therefore, allows for the value of time to be inferred from the data by estimating the proportion of the wage rate that most appropriately values a unit of time spent in different activities.

This approach appears to have been first forwarded by McConnell and Strand (1981). The result of their study was to suggest that travel time was valued at 60% of the wage rate for their sample of recreationists. More recently Jeng (1996) expanding on the McConnell and Strand model reports that the average visitor in a sample of bird-watchers visiting a wetland in Taiwan valued travel time at 23% of their wage rate. As far as the author is aware, this paper represents the first attempt to value the cost of time on site as well as that spent travelling.

It was assumed that each household in the data set had the average household income of their ennumerator area so that information on income could be taken from the census data contained in the GIS. The hourly wage variable for each household (w_n) was approximated by dividing annual after tax income by two thousand (an estimate of working hours in a year)[9]. Travel times (*tt*) were estimated from the distance travelled on roads of different qualities to and from the site and on site was taken as 12 hours per day, which assumes that the other 12 hours of each day spent on site would be spent sleeping or undertaking non-recreational activities.

[9] The same approximation has been used by a number of other researchers including Morey, Rowe and Watson (1993)

7. Sampling And Choice Set Definition

As described above a random sample of 1000 households resident in the Province of KwaZulu-Natal, was drawn from the original data set. A single visit made by each household to one of the game reserves was selected for inclusion in the final data set. One of the first tasks was to ensure that this visit was not part of a multiple-purpose trip. Travel cost methods rely on the assumption that a household enters into an implicit transaction. They 'exchange' the costs incurred in partaking in a recreational experience, for access to a recreational site. Their costs are effectively considered the price of the recreational experience. However, households frequently make multiple-purpose trips, in which visiting a game reserve may be only one of a number of objectives of the trip. As such, only a portion of the full travel costs can truly be said to represent the price a household is prepared to exchange for the recreation experience at the game reserve. Researchers frequently simply ignore such trips, since it has proved problematic establishing what proportion of the total trip travel costs should be attributed to the recreation experience as opposed to the other trip objectives. As the KwaZulu-Natal data set does not allow the direct identification of multiple purpose visits, two attempts have been made to minimise this possible bias.

- First, only trips made by residents of KwaZulu-Natal were included in the study. It was assumed unlikely that visitors from further afield would be on a single purpose trip. A similar assumption was made by Morey, Rowe and Watson (1993) in their model of Atlantic salmon fishing trips.
- Second, observations were removed from the database if it could be reasonably assumed that the household was staying at a number of different sites in the same trip. First, it was recognised that the game reserves made up only 4 of 14 parks and reserves administered by the Parks Board in the north-eastern region of Natal. It was considered fairly likely that households may decide to visit more than one of these sites in a single visit. Thus if a household was seen to reserve accommodation in any of these 14 parks for consecutive periods of time then this trip was assumed to represent a multiple-purpose trip. These trips were not included in the final data set.

Having established a final set of 1000 visits from the random sample of households, the next step was to define the set of options open to that household at the point in time when they made their choice of duration of stay, reserve and accommodation type. To achieve this a number of assumptions were made.

- First if the household had chosen a visit which that was consisted of staying in accommodation solely on a Friday and/or a Saturday night, then it was assumed that on that choice occasion the household was subject to institutional restrictions that meant they could not partake of a long duration visit.

- Second, it was assumed that households would only be prepared to stay in one type of accommodation for the duration of their visit, such that their visit would not be split between two accommodation types. As this was the case with all the actual choices made this assumption did not seem unreasonable.

The data provided by the KNPB allowed for exact identification of the units of accommodation available to the household on each choice occasion. An algorithm was written that searched through each accommodation type in each reserve identifying whether enough units of that type of accommodation were available in a single camp on consecutive nights to accommodate the household for the duration of the visit. The dates searched were restricted to include at least one of the days of the actual visit. Accommodation units were assumed to be available provided they were not being refurbished on those dates and provided they had not already been booked by another party at the time when that household had made their booking. The dates when individual units were being refurbished were available from the KNPB. Establishing if a unit had been previously booked was somewhat more complex. Each accommodation booking in the database is identified by a unique reference number that is allocated sequentially by the KNPB's reservations system. Therefore, an accommodation unit that had been booked with a reference number lower than that allocated to the household under consideration could not have been available to them when they were making their choice of accommodation. The algorithm identified all units of a specific accommodation type that were available to a household in a single camp in a given reserve for a given duration.

The choice set size of the households in the database are provided in Table 7.

Table 7: Distribution of sizes of choice sets in the data set

Choice Set Size	Number of Households		Choice Set Size	Number of Households
5	1		23	4
6	3		24	9
7	3		25	12
8	6		26	9
9	3		27	8
10	4		28	7
11	8		29	15
12	10		30	22
13	8		31	18
14	20		32	36
15	17		33	32
16	42		34	71
17	56		35	58
18	41		36	78
19	58		37	48
20	55		38	109
21	2		39	34
22	8		40	85

8. Results

Both the MNL model and the NMNL model were estimated using the final data set. The results of these regressions are presented in Table 8. In general, both models perform well; returning estimates of the parameters that have the envisaged signs and that are, in the most part, significant with greater than a 95% level of confidence.

8.1. Cost variables

The parameter estimated on the expenditure variable (i.e. the combined out-of-pocket costs of accommodation and travel) is negative and highly significant in both models. As we would expect, the marginal utility of expenditure is negative implying that the marginal utility of income (λ) is positive. The parameter takes a similar value in both models.

As discussed above, estimates of α_1 (the proportion of the wage rate that best monetarizes time on-site) and α_2 (the proportion of the wage rate that best monetarizes time travelling) can be retrieved from the parameters estimated on the two time variables. Thus for the NMNL model,

$$\alpha_1 = \frac{-.0022}{-.0065} = .344 \qquad \text{and} \qquad \alpha_2 = \frac{-.0097}{-.0065} = 1.492, \qquad (33)$$

whilst for the MNL model,

$$\alpha_1 = \frac{-.0027}{-.0054} = .502 \qquad \text{and} \qquad \alpha_2 = \frac{-.0048}{-.0054} = .884, \qquad (34)$$

As predicted by the De Serpa model, α_1 is less than α_2 since at the margin, time spent travelling is likely to confer disutility whilst time spent on-site is likely to confer utility. In other words, the cost of time spent travelling is higher than the cost of time on site.

The estimates of α_1 are relatively similar in the two models. The NMNL estimates that the price of time on-site as a third of the household wage rate whilst the MNL estimate is around a half of the household wage rate. As far as the author is aware these are the first published estimates of this parameter.

In contrast, the two estimates of α_2 are quite different. The NMNL returns an estimate of the price of time travelling at nearly one and half times the household wage rate which compares to a price estimated at under the wage rate coming from the MNL.

These estimates for the price of time travelling are generally higher than those returned by other researchers. Cesario (1976), using evidence from commuters travel decisions, proposed that the marginal value of travel time travelling could be approximated by one third of the wage rate. Smith, Desvousges and McGivney (1983) found no reason to suggest that using one third of the wage rate rather than the full wage rate was a better approximation of the opportunity costs of time spent travelling to water-based recreation sites. McConnell and Strand (1981) using a similar model to that presented here suggest that time travelling to recreation sites was valued at 60% of the wage rate. More recently Jeng (1996) expanding on the McConnell and Strand model reports that the average visitor in a sample of bird-watchers visiting a wetland in Taiwan valued time at 23% of their wage rate. However, the estimates from other studies are not entirely compatible with those presented here since they are based on individual not household data. It is possible that the estimate of household wage used in this research is relatively lower value per unit time per person because a number of members of the household are likely to be unwaged. Hence, it is not altogether surprising, that our estimates of the α_2 are relatively high.

8.2. Duration decision parameters

In the NMNL, the parameter on the long duration constant is negative and significant, suggesting that, *ceteris paribus*, households prefer short duration trips to long duration trips. A possible explanation for this is that institutional barriers exist that prevent households from taking long duration trips and that these barriers are not adequately accounted for in the assumptions used in the creation of choice sets.

The parameters estimated on the *Income*, *Holiday* and *Average Travel Cost* variables take similar positive and significant values in both models. It would appear that households are more likely to take long trips if they have higher income, if they are taking their trip during one of the holiday season periods and if they must travel further to reach the game reserves. The latter parameter is significant with 95% level of confidence lending support to the hypothesis that travel cost/time and time on site are positively related.

8.3. Reserve decision parameters

The reserve specific constants (*Hluhluwe*, *Itala* and *Umfolozi*) are all positive and significant at the 10% level of confidence or greater. As explained previously, these parameters can be interpreted as the relative preferences for the reserves compared to *Mkuzi* (the base case), given that all the other factors included in the model are constant. Both models, therefore, suggest that Mkuzi is the least favoured reserve and Hluhluwe is the most favoured reserve. In the MNL Umfolozi is preferred to Itala though this rating is reversed in the NMNL. The size of these parameters reflects a preference ordering for the reserves that might well be expected given the reserves' relative concentrations of game (see Table 1).

As expected, the parameter estimated on the distance travelled on *dirt roads* variable is negatively signed and in both models is significant at the 5% level of confidence; c*eteris paribus*, households would prefer to spend less time travelling on dirt roads to reach their destination.

8.4. Accommodation decision parameters

The variables included to characterise the accommodation types perform well in both models. All the variables are signed as would be expected; households are more likely to choose a certain accommodation type if it has a kitchen, if it has a bathroom and if it is in a camp which has a shop; they are less likely to choose a certain accommodation type if it involves splitting the household amongst several units and if the accommodation is constructed from canvas tenting. The model suggests that all else being equal households prefer not to stay in bush camps especially, not if they have juveniles and/or pensioners in the party. All the accommodation characterising variables are significant at the 5% significance level or better except, for the variable for accommodation types with bathrooms in the NMNL.

8.5. Comparison of the two models and the scale parameters

In general, the NMNL and the MNL return very similar results. Only one parameter, the constant for long trips, is differently signed and on the whole, the parameters have very similar magnitudes. Judging by the values of the maximised log likelihood functions, however, it is apparent that the NMNL provides a better fit to the data. A likelihood ratio test reveals that this is a statistically significant difference ($\chi^2 = 120.5$, $p < 0.001$).

The difference between the models is the inclusion in the NMNL of the scale parameters (λ_{lr} and δ_r). As described previously, these parameters allow for patterns of correlation to exist in the unobserved portion of the indirect utility functions (ε_{in}) of more similar options. More specifically one minus the scale parameter is a measure of the correlation of options gathered together in a particular nest. As such, a scale parameter taking a value of one indicates that no correlation exists within the set of options within a nest. Eight of the ten scale parameters estimated in the NMNL are significantly different from one at a 95% level of confidence, reinforcing the conclusion that the pattern of nesting imposed by the researcher is a better approximation of the correlation between the unobserved utility of the options than is the independence assumption of the MNL.

The NMNL model estimated here predicts a set of probabilities for each household choosing a certain duration/reserve/accommodation option. For this set of choice probabilities to be consistent with the random utility maximization framework which motivates the model then they must conform to a number of restricitve conditions. The conditions are laid out in Daly and Zachary (1979) and in McFadden (1981) and include such restrictions as all probabilities being nonnegative, the probabilities of the *i* options facing a household summing to one and the differences in the choice probabilities being dependent only on the differences in the observable portion of utility (V_{in}) of the options. The NMNL model fulfils all of these conditions automatically, except one. That condition is that the probability of choosing each option, P_i, must have non-negative even and non-positive odd mixed partial derivatives with respect to any distinct combination of V_j's, where $V_j \neq V_i$. This condition ensures that the probability distribution implied by the estimated model is a true probability distribution in so much as there will always be a non-negative probability that an option will be chosen (i.e. provide the maximum utility to the household). Daly and Zachary (1979) and McFadden (1981) have shown that for this condition to hold for all possible values of the observable portion of utility (i.e. for all $V \in R^I$), then the scale parameters must lie within the unit interval. That is;

$$0 \leq \lambda_{lr} \leq \delta_r \leq 1 \qquad (35)$$

This is known as the Daly, Zachary/McFadden (DZM) condition. For the model estimated here, the first part of the DZM condition holds, in that the scale parameters are all greater than zero and those at the higher level of nesting (δ_r) take on values that are greater than the values of the scale parameters for the nests lower in the hierarchy (λ_{lr}). However, the second part of the condition does not hold since both δ_r parameters take values that exceed one, and we might conclude that the estimated model does not conform to a random utility maximization hypothesis. Börsch-Supan (1990), however, highlighted the point that whilst the DZM condition is a prerequisite for global consisitency, it is too restrictive if one interprets the estimated NMNL as only a local approximation of the true underlying model based on the data provided by the sample. Börsch-Supan contends that it is too stringent to apply the limiting condition on the sign of the mixed partial derivatives to all possible values of *V*. Rather he proposes that consistency with random utility maximization should only be required to hold over those values of *V* which are reasonable for the particular application. Building on and correcting the work of Börsch-Supan, Herriges and Kling (1996) and Kling and Herriges (1995) have devised conditions under which a two-level NMNL model can be locally consistent (i.e. consistent over reasonable values of *V*). They devise a set of conditions that define the maximum value that may be taken by the scale parameters to ensure local consistency. In a complementary piece of work the author has extended these conditions to the three-level model and tested to see whether the estimated values for the scale parameters in this model can be considered locally consistent. The results of this research reveal that whilst the estimated model does not show global consistency, the values for the scale parameters presented her are locally consistent with random utility maximisation.

In conclusion, therefore, it would appear that the NMNL provides a significantly better model of recreational demand than does the MNL. The welfare estimates and further analysis presented in the next section, therefore, are based on the NMNL.

Table 8: NMNL and MNL models of recreational demand for trips to the game reserves of KwaZulu-Natal

Variable	NMNL	MNL
	Parameter Estimate (Asy. s.e.)	Parameter Estimate (Asy. s.e.)
Cost Variables:		
Accommodation and Travel Cost (tc + oc)	-.0065 (.0012)***	-.0054 (.0003)***
On-Site Time × Wage (w × ot)	-.0022 (.0006)***	-.0027 (.0005)***
Travel Time × Wage (w × tt)	-.0097 (.0028)***	-.0048 (.0010)***
Duration (Long trip specific):		
Constant	-3.231 (1.332)***	.305 (.652)
Income	.042 (.011)***	.045 (.009)***
Average Travel Cost	.017 (.010)**	.017 (.009)**
Holiday	.704 (.202)***	.593 (.193)***
Reserve:		
Hluhluwe Constant	1.403 (.442)***	.696 (.130)***
Itala Constant	1.064 (.460)**	.407 (.198)**
Umfolozi Constant	.713 (.489)*	.554 (.267)**
Dirt Roads	-.016 (.009)**	-.008 (.005)**
Accommodation:		
Accommodation Units	-1.932 (.389)***	-1.572 (.110)***
Shop	1.233 (.357)***	1.313 (.243)***
Tented Accommodation	-1.715 (.481)***	-1.543 (.243)***
Bathroom	.117 (.137)	.216 (.110)**
Kitchen	1.057 (.235)***	.987 (.106)***
Constant for Bush Camps	-.614	-.537

Variable	NMNL	MNL
	Parameter Estimate (Asy. s.e.)	Parameter Estimate (Asy. s.e.)
	(.268)**	(.204)***
Constant for Juveniles and Pensioners in Bush Camps	-1.636 (.543)***	-2.154 (.520)***
Scale Parameters:		
δ_{Short}	1.499 (.335)	
$\lambda_{Short, Hluhluwe}$	.738 (.117)**	
$\lambda_{Short, Itala}$	.351 (.070)***	
$\lambda_{Short, Mkuzi}$	.780 (.209)	
$\lambda_{Short, Umfolozi}$	.635 (.122)***	
δ_{Long}	4.221 (.972)***	
$\lambda_{Long, Hluhluwe}$	.245 (.066)***	
$\lambda_{Long, Itala}$	.186 (.056)***	
$\lambda_{Long, Mkuzi}$	.402 (.108)***	
$\lambda_{Long, Umfolozi}$	.276 (.078)***	
N	1000	1000
Log Likelihood	-2,446.73	-2,507.00

*** Significant at 1% level of confidence
** Significant at 5% level of confidence
* Significant at 10% level of confidence

9. Using the Recreational Demand Model to Measure Welfare Changes and to Aid Management Decisions

Models of recreational demand, such as those estimated here, can be put to a number of uses. Of particular interest in this case, is the use of the recreational demand model to answer economic questions concerning the value of the recreational experience to households (e.g. measure the welfare derived from the game reserves). However, the model is also provides a useful tool for management of the reserves, answering financial questions such as the impact of price changes or changes in the available facilities on revenues accruing to the KNPB. Let us deal with these in turn.

9.1. Answering economic questions: Measuring welfare changes

RUMs are motivated by the assumption that households choose options that provide them with the greatest utility. As such, researchers endeavour to estimate a function (V_{in}) that captures the influence of factors that it is assumed will influence the utility that is derived from the different options. However, Bockstael, McConnell and Strand (1991) point out that "given that special properties are not usually imposed on V_{in}, and more that utility is not an observable entity, the interpretation of V_{in} as related to indirect utility may seem stretch of faith". This caveat aside, welfare measurement, for models of discrete choice usually proceeds as described by Small and Rosen (1982).

Consider a household *n* faced with a set of options indexed by *i*. Let us denote the choice set of options available to the household when they make their decision as A_n^0. From the researcher's point of view, the expected maximum utility a household derives from this set of options can be written;

$$E\left[\max_{i \in A_n^0} V_{in}\right] \qquad (36)$$

Imagine now that one or more of the options open to the household were removed from the choice set. We could imagine, for example, that Umfolozi game reserve was converted to farmland, such that none of the options involving a trip to Umfolozi were available to the household. The household would now face a restricted choice set, A_n^1. Again the researcher can estimate expected maximum utility according to:

$$E\left[\max_{i\in A_n^1} V_{in}\right] \quad (37)$$

The decisions of a household that it is predicted would hardly ever choose the Umfolozi option will be relatively unaffected by this change in choice set. Their expected maximum utility, as calculated by the researcher, will remain relatively unchanged. Conversely, a quite marked reduction in the expected maximum utility would be predicted for households who, given the option, would frequently choose to visit Umfolozi.

For each household, therefore, we can define the change in expected maximum utility associated with removing one of the options from their choice set as:

$$E\left[\max_{i\in A_n^0} V_{in}\right] - E\left[\max_{i\in A_n^1} V_{in}\right] \quad (38)$$

For the three-level NMNL it can be shown that the expected maximum utility that a household will derive from a set of options is calculable as the natural log of the denominator of equation (11) (see Ben-Akiva and Lerman; 1987, for details). For example, if Umfolozi game reserve were to be closed, the number of options available to each household at the second level in the choice hierarchy would fall from four to three (i.e. the household could only choose to visit Hluhluwe, Itala or Mkuzi). Assuming Umfolozi to be the fourth of these options, the change in expected maximum utility derived by each household is given by the expression;

$$\ln\left[\sum_r (\sum_{l=1}^{4} (\sum_{i\in B_n^{lr}} e^{v_i / \delta_r \lambda_{lr}})^{\lambda_{lr}})^{\delta_r}\right] - \ln\left[\sum_r (\sum_{l=1}^{3} (\sum_{i\in B_n^{lr}} e^{v_i / \delta_r \lambda_{lr}})^{\lambda_{lr}})^{\delta_r}\right] \quad (39)$$

Simply put, equation (39) provides a measure of the utility the researcher predicts a household will lose if one of the reserves were not available to them.

To turn estimates of welfare loss into money measures we require an estimate of the marginal utility of income. The usual procedure, thus, is to recognise that in the absence of income effects the marginal utility of income is equivalent to the negative of the marginal disutility of expenditure. In the terminology of

Section 6, the marginal utility of income is denoted λ, and this is equal to the negative of the parameter estimated on the cost variable, i.e. $-\beta_I$. Thus dividing equation (39) by $-\beta_I$ gives a monetary measure of the welfare change, the compensating variation[8], experienced by households through the closure of the Umfolozi game reserve.

Following this procedure a value for the removal of each game reserve was calculated for every observation in the data set. These figures give the expected compensating variation for each choice occasion i.e. the amount of money that when given to the household after the closure of one of the parks would return them exactly to their original level of utility. The distribution of welfare changes in the sample for removal of the four reserves are illustrated in Figures 1 to 4. Values are presented in $US converted at the rate of exchange in 1994-95 of 1US$ = 3.5 Rand.

Figures 1 to 4 reveal that in general, the greatest loss in welfare for the sample would result from the loss of Hluhluwe game reserve as a recreational alternative. Whilst the majority of households would suffer welfare losses in excess of $50 per trip from the removal of Hluhluwe, only relatively few would value access to the other three reserves as highly. Umfolozi would appear to represent the second greatest loss to households in the sample whilst, in general, Mkuzi is the least valued of all the reserves. Notice that for Itala, the distribution of welfare loss has two peaks; a large peak in the low range between $10 and $20 per trip and a smaller peak in the high range between $60 and $70. This double peak is explained by the distribution of the population in KwaZulu-Natal. Referring back to Map 2, it is clear that the most densely populated areas in the province are around Durban and Pietermaritzburg in the south. For households travelling from these towns, Itala is the most distant of the game reserves. Hluhluwe and Umfolozi are much closer and provide the same, if not better, recreational opportunities. For the majority of households, therefore, the existence of substitute sites means that the loss of Itala from their choice set does not represent an enormous loss in welfare. On the other hand, for those travelling from the northern towns such as Vryheid and Newcastle, Itala is the closest reserve. Though not shown in Map 2, the road network in KwaZulu-Natal means that households in these towns have to travel relatively long distances to access the other three reserves. Hence for a small section of the population, Itala is highly valued.

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[8] Since the model assumes that there are no income effects, compensating and equivalent variation will amount to the same quantity.

Figure 1: Distribution of welfare loss for removal of Hluhluwe

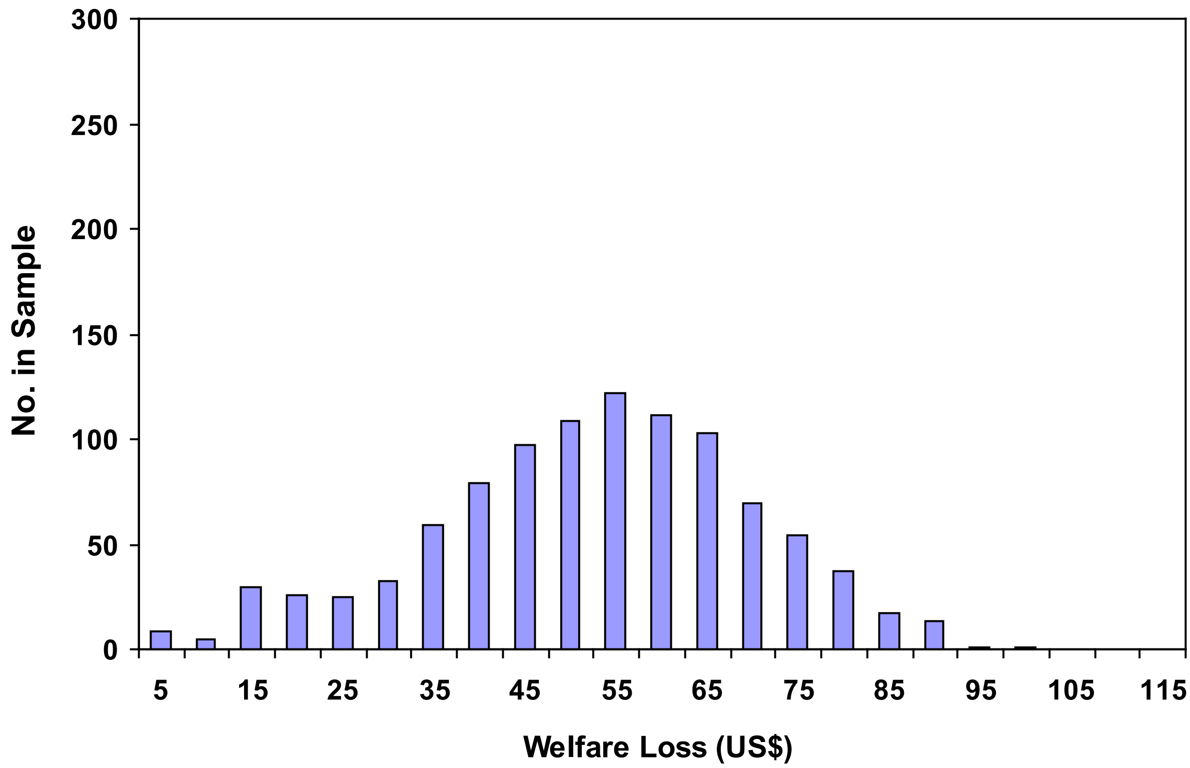


Figure 2: Distribution of welfare loss for removal of Umfolozi

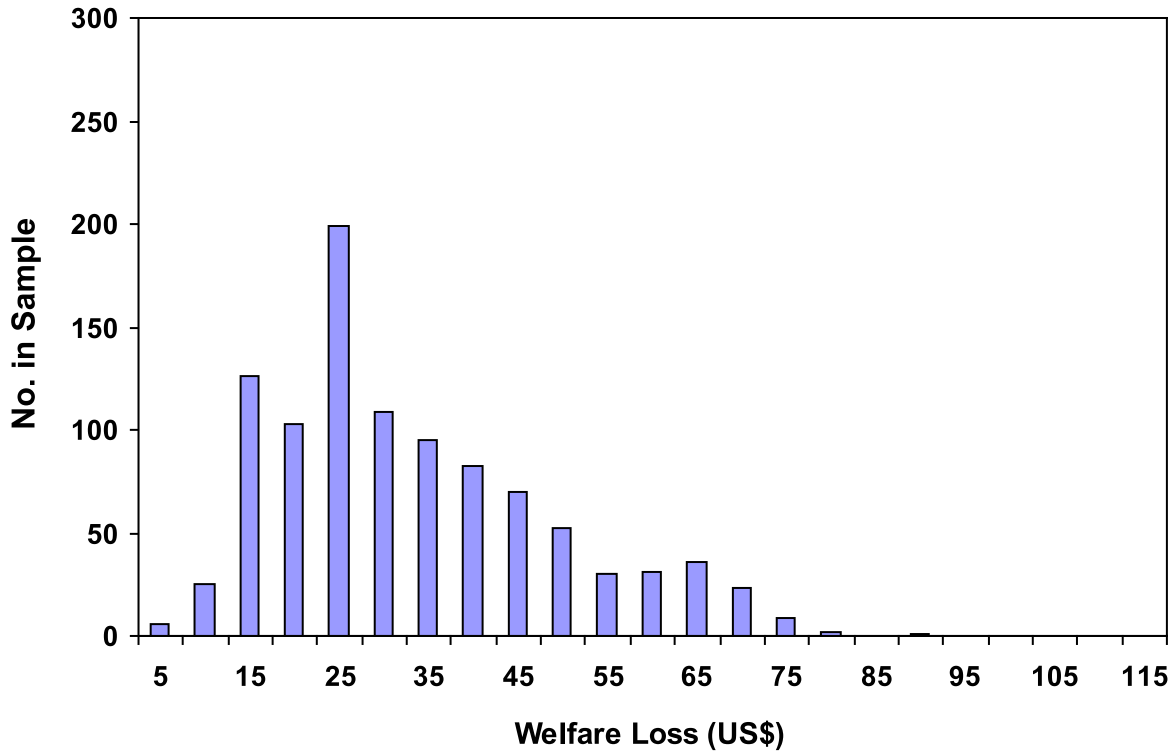


Figure 3: Distribution of welfare loss for removal of Itala

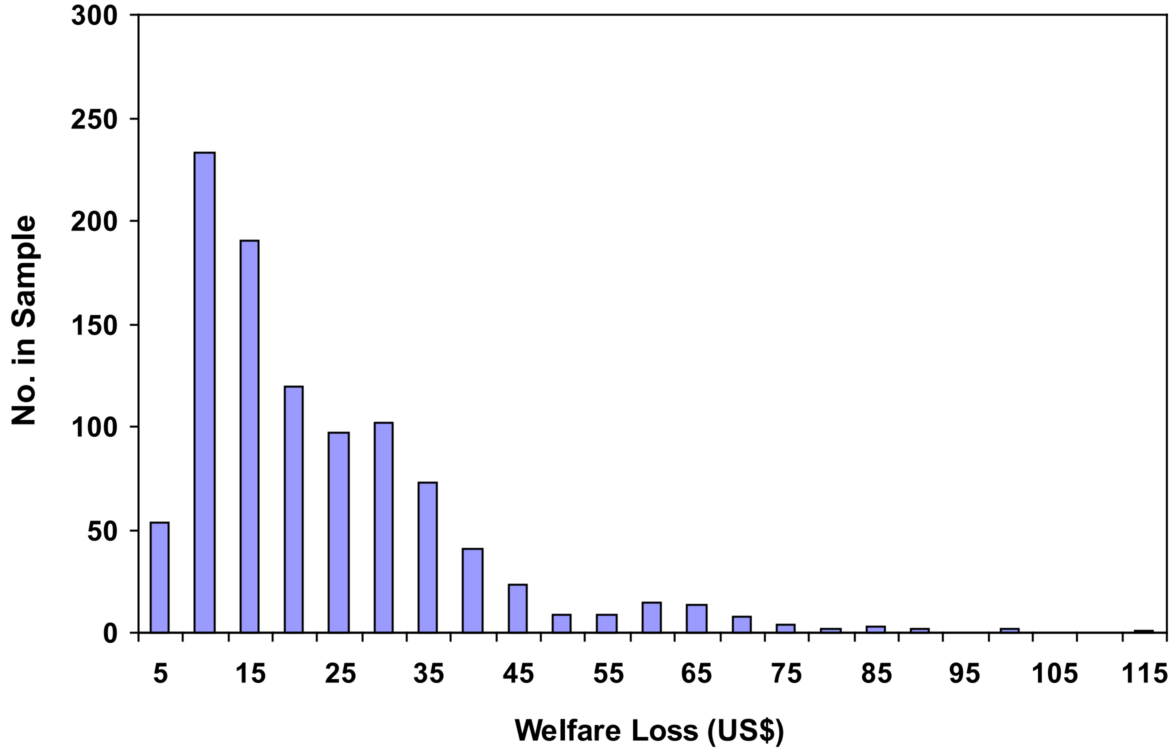
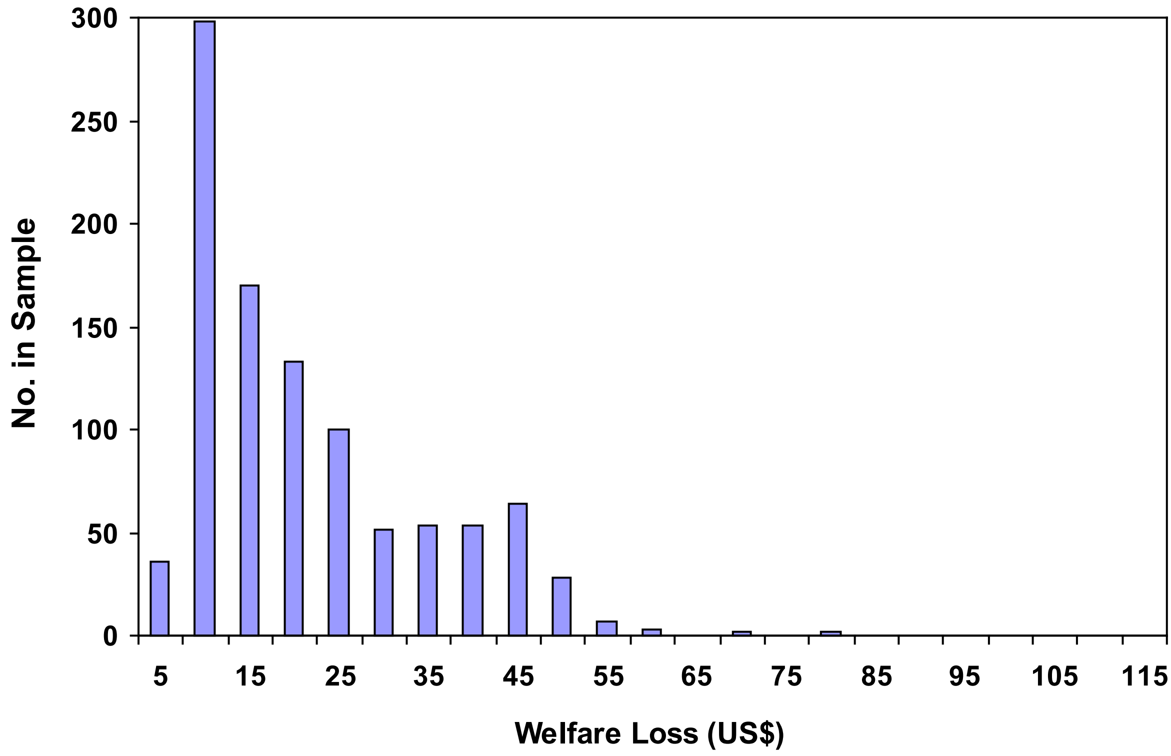


Figure 4: Distribution of welfare loss for removal of Mkuzi



For purposes of generalising to the population, it is useful to present summary statistics for these welfare changes. These are presented in Table 9. Notice that the estimates of per trip welfare loss are derived from an estimated model, such they themselves are only estimates of the true value placed by households on the reserves. As such, the welfare estimates should be presented with a confidence interval. One method for calculating a confidence interval is that proposed by Krinsky and Robb (1986). This approach uses the parameter and covariance matrix of these parameters estimated by the model, and assumes that these represent the means and covariance matrix of a multivariate normal distribution. A random draw from this distribution can be used to define a new set of parameter estimates that may be used to re-estimate the welfare changes. The Krinsky-Robb approach uses repeated draws to build up a picture of the distribution of the welfare estimates[10]. The 95% confidence intervals quoted in Table 9 are built up from 1000 Krinksy-Robb draws. The total values in Table 9, are derived by multiplying the average per trip welfare loss by the total number of visits made by households from KwaZulu-Natal to the four game reserves in the year 1994 to 1995 (9,533 visits).

Table 10: Per trip values for the game reserves of KwaZulu-Natal

Game Reserve	Average per Trip Welfare Loss (US$) (95% Confidence Interval)	Total Annual Welfare Loss (US$)
Hluhluwe	49.71 (± 7.38)	473,884
Umfolozi	30.47 (± 4.64)	290,448
Itala	20.37 (± 3.49)	194,169
Mkuzi	18.67 (± 3.57)	178,026
Hluhluwe and Umfolozi	105.55 (± 15.24)	1,006,208

[10] Note, this does not refer to the distribution of welfare losses across households. Instead the welfare loss is calculated repeatedly for each household using a new set of parameters randomly drawn from the assumed underlying distribution of these parameters.

The figures in Table 10 confirm our previous conclusions; on average Hluhluwe is the most valued of the reserves, with Umfolozi second and Itala and Mkuzi the least valued. This ordering for the per trip welfare loss concords with prior expectations. Hluhluwe and Umfolozi provide excellent game viewing opportunities whilst being more accessible to the major population centres in KwaZulu-Natal.

Table 10 also presents average per trip values for the loss of access to both Hluhluwe and Umfolozi. Notice that the value for the loss of both reserves simultaneously ($105.55) is considerable higher than the sum of the loss of both reserves individually ($80.18). This result clearly illustrates the importance of substitution and the benefits of using a model that allows for such effects. Since the Hluhluwe and Umfolozi reserves are located close to each other, removing either one of them allows households to substitute to the other reserve without losing too much welfare. If both are removed, the substitution possibilities are considerably diminished and households experience a large welfare loss.

The approach described above for deriving values for the different reserves can be adapted to answer a number of questions. For example, the value that would be lost to households if hut type accommodation were removed from Mkuzi game reserve would be $4.51 (R15.77) per household per trip. Similarly, it may be of interest to discover the welfare benefits of increasing the quality of a reserve by introducing new species or increasing the density of wildlife. Though the model does not provide enough detail to answer specific questions we could discover the welfare benefits of increasing the recreational experience at Itala to that to be to be found at Hluhluwe. In practical terms this entails calculating the increase in expected utility that would result if the value of the parameter on the Itala constant was made the same as that on the Hluhluwe constant. On average, such a calculation reveals that each household would realise an increase in welfare of $2.73 per trip (R9.55).

9.2. Answering financial questions; Predicting changes in revenue

Another possible application of the model is in the setting of pricing regimes for the reserves. Taking the sample of 1,000 households, it is a simple task to calculate the total revenue that the KNPB collected in entrance fees and accommodation charges. Of course, it would be of great advantage to the KNPB if they were able to predict how changing these prices would impact on their revenues. The model estimated here, provides a tool that allows just such predictions to be made.

As described in Section 4, the NMNL is a probabilistic model; it predicts the probability that a household will choose a certain option given the household's and the option's characteristics. One test of the quality of the model, therefore, is to see how closely the estimated probabilities of choosing an option concord with the household's actual choice of option. For example, if we multiplied the costs of each option by the predicted probability of choosing that option and summed this over all options available to a household and then over all households, we would hope that the expected revenue predicted by the model would be close to the actual revenue collected by the KNPB.

Table 11 provides just such a comparison. As we would expect, the actual and predicted revenues from entrance fees are identical, since entrance charges are identical across all the reserves. Reassuringly the revenues from accommodation charges predicted by the model are very close to the actual revenues, the two figures differing by just over 1%.

Table 11: Actual and predicted revenues

	Actual Payments made by Sample (US$)	**Payment Predicted by the Model (US$)**
Entrance Fee Revenues	7,850	7,850
Accommodation Revenues	133,237	131,558

Further, it is possible to use the model to predict how revenues would change if the KNPB were to change their pricing structure. For example, if the KNPB increased the entrance fee at Mkuzi by R15 per household (just under US$5), the model could be used to recalculate the probabilities of choosing each option taking into account the increased cost of visiting Mkuzi. Since the estimated model shows that higher costs reduce the utility of an option, we would envisage that increasing entrance fees of one set of options would reduce the probability that households would choose those options. Again we can multiply the recalculated probabilities by the costs to predict the revenues that might accrue to the KNPB following a price increase. Table 12 provides figures from this estimation for an increase in entrance fees at Mkuzi and at Hluhluwe. Three sets of revenues are listed, the present revenues, the revenues that would accrue to the KNPB if households did not change their behaviour following the price change and choose exactly the same option (i.e. not allowing for substitution), and the revenues predicted by the model allowing for substitution.

Table 12: Actual and predicted entrance fee revenues from the sample when charges are increased

	Actual Payments made at Present Prices (US$)	Predicted Payments Following Price Increase	
		Not Allowing for Substitution (US$)	Using the Model to Allow for Substitution (US$)
Charge at Mkuzi increased by R15 (US$5)	7,850	8,467	8,464
Charge at Hluhluwe increased by R15 (US$5)	7,850	9,612	9,575

The model predicts that increasing entrance fees by R15 at Mkuzi would increase revenues to the KNPB by 8% and by 21% if the same increase were instituted at Hluhluwe. Notice that the revenues predicted by the model are very similar to the revenues calculated not allowing for substitution. It seems that increasing entrance fees by R15 has only a small impact on the choice of site made by households.

One short-coming of the model presented here, however, is that it does not allow for households to substitute away from taking a recreational trip to a game reserve. Consequently, the predicted revenues presented here are likely to be over-estimates since they do not allow for the possibility of households responding to price increases by not visiting a reserve at all. In a complementary piece of work, the author has estimated a model in which the decision to participate or not participate in a recreational trip to a game reserve is taken as an extra option in the choice set. Households are assumed to make such a decision in each of several periods over the year. This is essentially the approach taken by Morey, Rowe and Watson (1993). The results of this research are not presented here.

A second question the KNPB may wish to address is the pricing of accommodation in the reserves. Table 13 gives revenue projections for changes in the cost of chalet type accommodation in all the reserves. If we were to make our calculations without allowing for substitution away from the chalet accommodation option, then a price increase of R15 per person per night would result in an increase in revenues of some $17,326. However, it would appear that substitution is an important factor since when the expected revenues following the price increase are calculated using the model, the increase in revenues is predicted to be only $2,891. The importance of substitution is made even clearer when we use the model to predict the increase in revenues following an increase in the price of chalet accommodation of R35 (US$10) per person night. If households exhibited no substituting behaviour, then revenues would increase by $40,426. However, using the model to predict substituting behaviour, the price increase results in a predicted fall in revenues of $1,679 as households switch away to cheaper accommodation types.

Table 13: Actual and predicted accommodation revenues from the sample when chalet accommodation increased in price

	Actual Payments made at Present Prices (US$)	Predicted Payments Following Price Increase	
		Not Allowing for Substitution (US$)	Using the Model to Allow for Substitution (US$)
Chalet accommodation increased by R15 per person night	133,237	150,563	136,128
Chalet accommodation increased by R35 per person night	133,237	173,663	131,558

The NMNL is a recreational demand model that can be used to answer a number of questions that may be of interest to decisions makers. These questions may be either economic in nature concerning, for example, the welfare derived from access to the reserves, or financial concerning, for example, the changes in revenues that might result from changing pricing structures.

10. Summary and Conclusions

Some thirty years of research have seen the travel cost demand model evolve into a broad family of approaches to modelling recreational demand behaviour (Smith, 1989). One approach which has curried particular favour with researchers in recent years is that based on McFadden's (1974) random utility framework. The discrete choice nature of RUMs allows researchers to focus on how households choose between substitute sites for any given recreational trip, a question that traditional continuous models had found difficult to answer.

Empirical applications of these models abound. In general, however, the literature tends to be dominated by studies of water-based recreation in the United States (though see Morey, 1981, for an application to Colorado skiers, and Yen and Adamowicz, 1993, for an application to Bighorn sheep hunters in Alberta, Canada). Several studies have investigated the choice between different fishing locations based on angler success rates or fish species densities (e.g. Bockstael et al., 1989; Morey et al., 1993; Hausman et al., 1995; Kling and Thomson, 1996) whilst many others have concentrated on the choice between recreation sites based on water quality (e.g. Feenberg and Mills, 1980; Caulkins et al., 1986; Parsons and Kealy, 1994; Kaoru et al., 1995, Feather et al., 1995). This paper introduces a unique dataset from South Africa which records the visits of domestic tourists to the four large game reserves in the province of KwaZulu-Natal.

The data is derived from the KwaZulu-Natal Parks Board's (KNPB) reservation database. This database records a great deal of information on households visiting the various parks and reserves administered by the KNPB. The quality of the dataset allows much more accurate definition of the choices available to visitors when planning their trip. Also, the postal addresses of visitors to the game reserves have been used to derive extremely accurate measurements of travel costs and travel times using a GIS. The GIS has also be employed to associate visitors with the census data for the enumerator area (the smallest unit of the South African census) in which they reside. The census returns give indications of the socioeconomic characteristics of the households in the sample.

Since the best times of day for viewing wildlife are at dusk and dawn and given that the game reserves of KwaZulu-Natal are located in relatively remote regions of the province, visitors typically stay for one or more nights in the reserve. This fact introduces two important elements into the modelling of demand for recreational trips that have been largely ignored or assumed away in other RUM applications.

Firstly, given that the time households stay on site is an endogenous decision that influences the utility they realise from any one trip to a reserve, a model of recreational demand should allow for the choice of length of stay.

Second, since visitors tend to spend at least one night in the reserve, they must purchase overnight accommodation. In each of the four reserves the KNPB provides a variety of tourist accommodation facilities. Accommodation facilities vary greatly in their quality and hence price. In effect, household's enjoy a third dimension of choice on top of the choice of reserve and length of stay, they can influence the cost and quality of their visit through their choice of on-site accommodation.

The three dimensions of choice facing visitors to the game reserves have been modelled using a three level NMNL. An option is defined as the choice of a particular type of accommodation in a particular reserve for a particular length of time. The structure of the model allows investigation of an important issue in recreational demand modelling, namely the specification of the 'travel cost' variable. It is clear, that visitors to the reserves are faced by an number of financial costs, including; their expenses in travelling to and from the reserve, their expenses in entrance fees, their expenses on accommodation and a number of opportunity costs, specifically; that of time spent travelling and time spent on site. Following the suggestion of Cesario and Knetsch (1970), it has been common practice amongst travel cost practitioners to monetarize and aggregate these expenses into one 'total cost' variable. But as authors such as De Serpa (1971), Cesario (1976) and Wilman (1980) have pointed out, the value of time spent in different pursuits will depend on the degree to which time spent in that activity is utility raising or decreasing. The model presented here estimates the value of time travelling and time spent on site. This value can be translated into a proportion of the wage rate that best monetarizes time spent in these two activities. As expected time travelling is considered more costly to the household (150% of the household wage rate) than time spent on site (34% of the household wage rate).

Depending on assumptions made by the researcher the random utility framework gives rise to a number of specific models. Due to their computational simplicity researchers have tended to favour the MNL and the NMNL. The NMNL partially avoids the MNLs well-known independence of irrelevant alternatives (IIA) property, by allowing similar options to be grouped in a manner that allows the unobserved portion of utility (ε_i) derived from options to be correlated. The results of this research show that, for this data set, the NMNL provides a better approximation to this pattern of correlation than the independence assumed by the MNL.

The three-level NMNL has been estimated using full information maximum likelihood procedures and separate scale parameters estimated for each nest. Though the scale parameters do not conform to the DZM conditions, they are shown, in a separate piece of work, to be locally consistent with random utility maximization.

The NMNL is a recreational demand model that can be used to answer a number of questions that may be of interest to decisions makers. The model estimated here has been used to answer both economic questions, such as valuing the welfare derived from access to the reserves, and financial questions, such as predicting the changes in revenues that might result from changing pricing structures.

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