The value of the trout fishery at Rhodes, North Eastern Cape, South Africa: A travel cost analysis using count data models

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Abstract

The National Environmental Management: Biodiversity Act, no.10 of 2004) makes provision for the presence of alien trout in South African waters by means of a zoning system, partly in recognition of the significant income generating potential of trout fishing in South Africa. This paper reports the first formal recreational valuation of a trout fishery in South Africa, the one in and around Rhodes village, North Eastern Cape. The valuation is carried out by applying the individual travel cost method using several count data models. The zero truncated negative binomial model yielded the most appealing results. It accounts for the non-negative integer nature of the trip data, for truncation and over-dispersion. The paper finds that in 2007 consumer surplus per day visit to the Rhodes trout fishery was R2 668, consumer surplus per trip visit was R13 072, and the total consumer surplus generated was R18 026 288.

1 Introduction

The merit of the presence of Rainbow and Brown trout in South African waters has been challenged in recent years by increased negative publicity toward alien plants and animals (Bainbridge *et al.*, 2008). In total twenty-four alien fish species, equivalent to 9 % of all South African freshwater fish species, were introduced into and established in South African waters during the 19^{th} and 20^{th} Centuries (Skelton, 2001). Of the twenty-four introduced species, trout have become South Africa's most widely spread and used freshwater fish species – mainly because they are in such high demand as a target for recreational fishing (Bainbridge *et al.*, 2005). The trout fishing industry has already been shown to be a source of income, as well as a job creator, in some of the poorest, most rural parts of South Africa (Bainbridge *et al.*, 2005; Hlatswako, 2000; Rogerson, 2002). The industry provides a two-tier service: first, in food production and second, as a recreational angling resource. Recreational angling, including fly-fishing for trout, is a major tourism attraction in South Africa (Bainbridge *et al.*, 2005). The trout fishing industry is sustained and underpinned by a considerable service industry consisting of tackle manufacturers and retailers, tourist operators, professional guides, hotels, lodges and bed and breakfast establishments. The trout is also viewed as an indicator of good water quality in South African streams and rivers.

The National Environmental Management: Biodiversity Act, no. 10 of 2004 (NEMBA) explicitly recognizes the value of trout and makes provision for their management. Both trout species have been listed in Category 4 of the NEMBA Alien Regulations for alien animals and plants, to be managed by way of a zoning system (Impson, 2008). Within the zones trout fishing will be promoted but

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outside the zones, however, trout fishing and farming will be controlled (Impson, 2008). "...every effort will be made to protect premier trout waters in South Africa. Everyone is aware that these waters are economically valuable and cherished by a substantial number of South Africans" (Impson, 2008).

One of these premier trout waters is the Rhodes fishery situated in the North Eastern Cape, South Africa. The rivers and streams that make up the Rhodes fishery are easily accessible and mainly inhabited by a self-sustaining population of wild trout (both Rainbow and Brown). If one were to eradicate the trout in this region (because it is an alien species) there would be substantial costs incurred. The most feasible way would be poisoning – but even this would be very costly – direct costs plus those of eradicating other species and foregone recreational value.

How big would the opportunity cost be? This study is the first formal attempt to value this cost - the recreational trout fishery in South Africa. A specific trout fishery was selected for this purpose - the one in and around Rhodes village, North Eastern Cape[1].

The method adopted in this paper to value the trout fishing benefit is the individual travel cost method. This method is well suited to valuing the benefits of a trout fishery because travel cost is often the main expenditure incurred by a cross-section of fly-fishers (Loomis & Walsh, 1997). Due to the count, truncated and over-dispersed nature of the data count data models were estimated in this study.

2 The travel cost method

Many travel cost studies have been conducted in the United States and elsewhere to value recreational sites (Caulkins *et al.*, 1986; Kling, 1987; Liston-Heyes & Heyes, 1999; Bowker *et al.,* 1996; Fix & Loomis, 1997; Bin *et al.,* 2005; Martinez-Espineira & Amoako-Tuffour, 2008). Examples of the application of the method to value recreational fisheries include Morey *et al.* (1993), Layman *et al.* (1996), Gillig *et al.* (2000), Curtis (2002) and Shrestha *et al.* (2002). Morey *et al.* (1993) and Curtis (2002) employed the travel cost method to estimate the value of Atlantic salmon recreational fisheries – one in the United States and the other in Ireland. The consumer surplus per day trip was estimated as US$179 and IRPound139, respectively for the Morey *et al.* (1993) and Curtis (2002) studies. The travel cost method was also used to estimate values for recreational fisheries located in Alaska, the Gulf of Mexico and the Brazilian Pantanal (Layman *et al.*, 1996; Gillig *et al.*, 2000; Shrestha *et al.*, 2002). The consumer surplus of a single day trip to the Red Snapper fishery in the Gulf of Mexico was estimated at US$213 (Gillig *et al.*, 2000), whereas the consumer surplus of a single day trip to Brazilian Pantanal recreational fishery was estimated at US$86 (Shrestha *et al.*, 2002). Layman *et al.* (1996) estimated the consumer surplus per trip to the Alaskan salmon recreational fishery to be US$51.

Travel cost models can be broken up into single-site and multiple-site ones. The latter include Random Utility Models (RUMs), whereas the former include the individual and zonal (Clawson-Knetsch) methods (Bockstael, 1995; Freeman, 2003). A single-site individual travel cost method (TCM) was applied in this study to estimate the total economic value of the Rhodes trout fishery.

To perform the individual TCM analysis, a trip generating function (TGF) is estimated using survey data in which travel costs predict the number of visits that will be undertaken by an individual to a recreational fishing site (Bockstael, 1995; Pagiola *et al.*, 2004; Ward & Beal, 2000). The travel cost incurred in undertaking the fishing trip to the site is therefore used as a proxy for the "price" paid by the visitor for the site's use (Liston-Heyes & Heyes, 1999). Over and above travel costs, a range of explanatory variables (such as income, age, gender, educational attainment, substitute sites and recreation site quality) are also usually included in the TGF (Bockstael, 1995; Hanley & Spash,

[1] Other applications of the valuation to trout fisheries include: assistance in fishery management decisions, such as awarding zoning rights for trout fisheries in upper catchments, and determining the benefits associated with water quality improvement projects (McConnell and Strand, 1994).

1993). Once the TGF is estimated, a demand function can be derived which is used to estimate the consumer surplus or non-market value of recreational fishing (Bateman, 1993; Hanley & Spash, 1993).

Due to the zero truncated and non-negative integer nature of the trip data as well as the prevalence of over-dispersion issues, the estimation of the TGF by means of the ordinary least squares (OLS) method may lead to biased estimators (Creel & Loomis, 1990; Hellerstein & Mendelsohn, 1993). As a result of these difficulties with the OLS model, the use of count data models, such as the Poisson and Negative Binomial models, have become popular (Creel & Loomis, 1991; Hellerstein, 1991; Bowker *et al.,* 1996; Englin *et al.,* 2003). The standard Poisson model assumes a discrete probability density function and non-negative integers (Hellerstein & Mendelsohn, 1993; Shrestha *et al.,* 2002).

The truncation problem is common in modelling recreational demand because of on-site sampling. Non-visitors' demand and the value they attach to the recreational site in question are not captured and therefore is excluded (Bin *et al.,* 2005; Englin & Shonkwiler, 1995). The endogenous stratification problem is the increased likelihood that more frequent than less frequent visitors will be captured during the administration of the surveys biasing the sample toward this group (Shaw, 1988; Creel & Loomis, 1990).

The recommended procedure to correct for both endogenous stratification and truncation is to weight each observation by the expected value of visits (Shaw, 1988). When the standard Poisson model is applied, this correction procedure entails modifying the dependent variable by subtracting 1 from each of its values (Shaw, 1988; Fix & Loomis, 1997; Hesseln *et al.,* 2003; Hagerty & Moeltner, 2005).

A drawback of the Poisson model is that it assumes that the first two moments (variance and conditional mean) of its distribution are equal. In many instances the conditional mean and the variance are unequal - the variance exceeds the conditional mean causing over-dispersion (Cameron & Trivedi, 1990).

Use of the negative binomial model is a popular way of addressing the over-dispersion problem (Shrestha *et al.,* 2002; Bin *et al.,* 2005; Martinez-Espineira & Amoako-Tuffour, 2008). The unobserved heterogeneity that is not captured by the Poisson model is reflected in the negative binomial model by the addition of an extra parameter, α (Martinez-Espineira & Amoako-Tuffour, 2008). In order to test for no over-dispersion, a likelihood ratio test based on the parameter α can be administered. The negative binomial model can also be adapted to correct for truncation; yielding a zero truncated negative binomial model (Bowker *et al.,* 1996; Liston − Heyes & Heyes, 1999; Zawacki *et al.,* 2000; Martinez-Espineira & Amoako-Tuffour, 2008).

3 Applying the TCM to value trout fishing

The TCM is a highly appropriate method by which to value recreational assets such as trout fishing waters because the main way demand is revealed is through travel to access these waters. The specific waters valued are those in and around Rhodes village, located at the foot of the southern Drakensberg Mountains in the North-Eastern Cape (See Fig. 1 below).

Commercial activities in the Rhodes region comprise of farming and tourism-related businesses. The latter include accommodation provision (for example, lodges and guesthouses), tourist guide services and art products. One of the main tourist attractions located in and around Rhodes village are the many rivers and streams which harbour an abundance of self sustaining populations of wild trout (both Rainbow and Brown) (Wild Trout Association, 2008). The streams and rivers originate 2800 to 3300 metres above sea level as unspoiled, rock-based highland streams. The Wild Trout Association (WTA) manages the rivers and streams on behalf of riparian landowners (Wild Trout Association, 2008). Visiting fly-fishers pay a R100 fee per day to fish in the WTA's waters. The riparian landowners receive R60 of each R100 paid by fly-fishers, while the WTA retains the balance

(Wild Trout Association, 2008). The permit allows access to more than 200 kilometres of running water. The fishing season in the Rhodes region runs from September to March of every year (Senqu Tourism, 2008).

The trip data required to apply the individual travel cost method in this study was obtained by conducting on-site personal interviews with the aid of a structured questionnaire between September 2006 and September 2007. The target population comprised of all the users of trout and trout fly-fishing services provided by the rivers and streams managed by the WTA. The sampling frame was defined in terms of fly-fishers who purchase day permits from the WTA in order to gain access to the rivers and streams. By averaging total annual visits (based on individual day permit sales) to WTA-rivers and streams from 2002 to 2006 it was estimated that 700 fly-fishers visit Rhodes per annum. Every seventh adult respondent purchasing a day permit from the one and only WTA day permit vendor in Rhodes was selected. A sample of 13% of the estimated fisher population was targeted, viz. 96 fishers.

The interviewer was instructed to conduct the interviews with individuals only so as prevent the influence of others if it was a group visit. In cases where families were encountered, the interviewer was requested to interview the household head only.

In the survey visitors were asked questions about the their home location, the round trip distance travelled, the duration (in hours) of the round trip, the type and engine capacity of the motor vehicle used to undertake the trip, duration of the visit, the total number of trout caught during visits undertaken to the site during the previous year, the time taken to travel to their favourite substitute trout fishing site, other sites and attractions visited during the trip and some socio-economic information.

No thorough examination of the characteristics of the fly-fishers who visit the Rhodes trout fishery has ever been conducted. For this reason, it was difficult to determine whether this sample is representative of the typical population of visitors to Rhodes. The only data available for comparison purposes was that of visitor origin for the period 2002 to August 2006 – see Table 1 (Wild Trout Association, 2008).

The records of the population and those of the sample show similar characteristics.

The TGF used predicted visit frequency on the basis of a mixture of trip characteristics such as travel costs, travel time, socio-economic variables (income, gender, age, and race), a substitute site variable and an environmental quality variable and was specified as follows:

$$V_{ij} = f(TC_{ij}, TT_{ij}, SE_{ij}, S_{ij}, E_{ij}); \; i = 1 \ldots n \tag{1}$$

where V_{ij} is the number of trips undertaken tothe site per annum, TC_{ij} is the travel cost incurred in visiting site j, TT_{ij} represents the round trip travel time, SE_i represents various socio-economic characteristics of the respondent, S_{ij} represents information on substitute sites, E_{ij} represents information on environmental quality and n is the number of visitors .

The dependent variable in this study is the number of trips undertaken to Rhodes by the individual in the past year. It was hypothesized that travel cost, travel time, gender, race, catch rate, age, income and substitute sites would explain the number of fishing trips undertaken to Rhodes.

The travel costs for each respondent were the sum of distance costs and accommodation costs. The latter was taken to be the reported cost per night of staying in Rhodes. The distance costs were calculated by the researchers from motor vehicle operating costs. Some studies use reported travel (distance) costs (Fix and Loomis, 1998) while other studies use researcher-calculated travel costs (Martinez-Espineira and Amoako-Tuffour, 2008). Bowker *et al.* (1996) found no significant dissimilarities between the methods, Common *et al.* (1999) found that 'researcher assigned costs' are 33 percent above respondent perceived costs and Hagerty and Moeltner (2005) found that travellers behave in a way that suggest that their individual travel costs per mile are less than those based on engineering considerations. The latter suggests that individuals are either ignorant of true travel costs, or that there exists unaccounted for factors related to driving which have a 'cost-decreasing effect' (Hagerty and Moeltner, 2005). The calculation of the travel costs by the researchers in this study was done in an attempt to prevent respondent fatique, and recollection and response bias (Martinez-Espineira & Amoako-Tuffour, 2008).

Following standard practice in the literature (Hesseln *et al.,* 2003; Bin *et al.,* 2005; Martinez-Espineira & Amoako-Tuffour, 2008), the total operating costs per kilometre were multiplied by the roundtrip distance (to and from Rhodes) travelled. Total operating costs were estimated by summing the fixed costs and running costs of operating a motor vehicle, as provided by the Automobile Association of South Africa (AA). The fixed costs include the cost of licensing, depreciation and insurance. To compute the running costs of a motor vehicle, the AA uses the engine capacity, the annual maintenance costs and the fuel costs per kilometre.

The inclusion of time costs in travel cost studies has been subject to much debate (Freeman, 2003; Zawacki *et al.*, 2000; Hesseln *et al.*, 2003; Parsons, 2003; McKean *et al.*, 2003). Some studies suggest that some fraction of the wage rate be used to estimate the opportunity cost of time (Cesario & Knetsch, 1970; Cesario, 1976; Bateman, 1993; Bowker *et al.,* 1996; Liston-Heyes & Heyes, 1999; Zawacki *et al.,* 2000; Hagerty & Moeltner, 2005; Martinez-Espineira & Amoako-Tuffour, 2008). Travel time costs ranging between 25% and 50% of the wage rate are commonly thought to be appropriate (Bateman, 1993; Bowker *et al.*, 1996; Zawacki *et al.*, 2000), particularly 30% (Sarker & Surry, 1998; Liston-Heyes & Heyes, 1999; Sohngen *et al.*, 2000; Hagerty & Moeltner, 2005; Martinez-Espineira & Amoako-Tuffour, 2008). Normally, the time cost of travelling is calculated as the product of the number of hours travelled and the opportunity cost of time per hour (the hourly wage rate multiplied by a fixed fraction). Some studies calculate the hourly wage rate for each individual by dividing their annual income by total number of working hours per annum (Bin *et al.*, 2005; Martinez-Espineira & Amoako-Tuffour, 2008). Other studies choose to omit travel time costs completely (Hanley *et al.*, 2003). In this study, the round trip travel time variable is treated separately, so permitting the calculation of the opportunity cost of travel time endogenously (Loomis & Walsh, 1997; Shrestha *et al.,* 2002).

The following socio-economic variables were also included, gender, race, age, and income. Many travel cost studies have found income to have a negative or non-significant influence (Liston-Heyes & Heyes, 1999; Sohngen *et al.,* 2000; Loomis, 2003). Others have found income to have a positive and significant influence (Bin *et al.,* 2005; Martinez-Espineira & Amoako-Tuffour, 2008). Being very remote makes the visit and fishing at Rhodes village expensive enough for many fly-fishers. For this reason it was expected that income would have a positive influence (recreational fishing being a normal good) on the number of fishing trips undertaken per annum.

The TGF should, ideally, also include a substitute site variable because two visitors who travel an equivalent distance to visit a recreation site may value it entirely differently. The differences in valuation of a site by the two visitors may be because one visitor has a substitute site available while the other does not (Bateman, 1993; Hanley & Spash, 1993; Perman *et al.*, 1996). This influence can be incorporated by including distance to a substitute site as a variable or a dummy variable that assumes a value equal to one if the individual suggested a substitute site was considered or zero if not (Bowker *et al.,* 1996; Martinez-Espineira & Amoako-Tuffour, 2008). Many studies omit the price of substitutes (Creel & Loomis, 1990; Liston-Heyes & Heyes, 1999). Smith and Kaoru (1990) have argued that the omission of substitutes leads to an over-estimation of consumer surplus. In this study, the influence of substitute sites on visitation rates is reflected by the person's roundtrip travel time (measured in hours) to his or her most favoured alternative (substitute) site.

The environmental quality variable included in the TGF depends on the type of recreation site being valued. Examples of environmental quality indicators are the level of pollution, the availability and quality of infrastructure at the site, temperature, and the amount of congestion at the site. In recreational fishing studies, the catch rate variable is a common environmental quality indicator (McConnell & Strand, 1994). It was also used in this study. Table 2 provides the operational definitions and *a priori* expectations of the variables used in constructing the recreational demand model of trout fly-fishing.

The descriptive statistics of the variables used in the regression analysis are shown in Table 3.

The majority (98%) of the fly-fishers interviewed were white males. Respondent age ranged between 19 and 69 years, with a mean age of 41 years. The survey also revealed that 16% of respondents earn in excess of R1 million per annum compared to only 6% who earn R120 000 or less per annum. The average income was R848 020 per annum. On average, visitors caught a total of 35 trout during trips undertaken in the previous year.

4 The multi-purpose trip problem

The issue of multi-purpose trips is a problem that is unique to the application of the TCM (Bateman, 1993; Freeman, 2003; Martinez-Espineira & Amoako-Tuffour, 2008). Normally, a custom is followed whereby "meanderers" are distinguished from "purposeful visitors" (Hanley & Spash, 1993). The former are those people for whom a recreational site visit is only part of the reason for their journey. The latter are those people for whom a recreational site visit is the only reason for their trip. It is very difficult to allocate a proportion of travel costs to meanderers (Hanley & Spash, 1993). It has been shown by Martinez-Espineira & Amoako-Tuffour (2008) that ignoring the multi-purpose nature of trips leads to an over-estimation of consumer surplus by almost 50%. The problem of multi-purpose trips is also encountered in fly-fishing visits. In order to deal with this issue, respondents were asked to score the importance of fly-fishing for trout, among other activities, relative to the importance they attach to the entire trip. The score, expressed as a percentage, was then used to weight their aggregate travel cost. Weighting the aggregate travel cost per fisher resulted in the following transformation:

$$WTC = ATC * w \tag{2}$$

where WTC is the weighted aggregate travel cost per fisher, ATC is the unweighted aggregate travel cost per fisher, and w is the weighting factor expressed as the percentage time spent fly-fishing for trout. The majority of the respondents, namely 89%, stated that the sole reason (a 100% score) for their trip was to fly-fish for trout in the Rhodes fishery.

5 Results and discussion

Four types of econometric specifications were used in this study to estimate a recreational fishing trip demand model, namely a standard Poisson specification, a Poisson specification adjusted for truncation and endogenous stratification (ES Poisson), a standard negative binomial specification (NB), and a zero truncated negative binomial specification (ZTNB).

The same covariates were used in each of the abovementioned estimations. In addition, separate slope parameters were estimated for the different specifications, because the estimated coefficients of the Poisson and negative binomial models can not be interpreted as marginal effects. The results of applying various count data models in Stata: Release 10.1 are shown in Table 4 below.

The different models of recreational demand presented in Table 4 above are robust − there are no coefficient sign changes across models, the magnitudes of the coefficients are very similar, and only the statistical significance and the goodness of fit measures are slightly dissimilar. According to Table 4, the Poisson model (ES Poisson) adjusted for zero truncation and endogenous stratification best fits the data (the Pseudo $R^2 = 0.1246$ and six of the eight explanatory variables are statistically significant).

Over-dispersion is a problem since the over-dispersion parameter α in both the negative binomial (NB) and the zero truncated negative binomial (ZTNB) models is highly significant. More specifically, a likelihood-ratio test of α equal to zero based on the NB results in a $\overline{\chi}^2$ (01) = 80.92 with $Prob\!>\!= \overline{\chi}^2 = 0.000$, while a likelihood-ratio test of α equal to zero based on the ZTNB results in a $\overline{\chi}^2$ (01) = 83.81 with $Prob\!>\!= \overline{\chi}^2 = 0.000$. Both the recreational demand models based on the Poisson distribution, namely Poisson and ES Poisson, are overly restrictive because they do not take into account that a small number of fishers undertake many trips while a large number of fishers undertake only a few trips – a problem that is averted by the use of the negative binomial model. Although both negative binomial models account for the count nature of the data and over-dispersion, the ZTNB model is preferred over the NB model, since the former also accounts for zero truncation. Moreover, both the log-likelihood function value and the information measures (AIC and BIC) suggest that the ZTNB model performs better than the NB model. The discussion below relates to the preferred ZTNB model.

Estimates of the ZTNB model show that the estimated coefficient for the travel cost variable is negative and significant (Table 4). The negative sign of this variable's coefficient suggest a downward-sloping demand curve – fishers undertake fewer trips as travel costs rise. This result is strongly reinforced by the coefficient of the travel time variable – it has a negative sign and is statistically significant at the 10% level. The marginal effects of the travel cost and travel time variables can be used to estimate the opportunity cost of travel time. An increase of R1757.78 in travel cost entails a one-trip decrease in visitation (calculated from Table 4). A decrease of one trip entails an increase of 8.40 hours in travel time. Therefore, an hour of travel time costs R209.26 in recreational fishing. Coincidently, the magnitude of this travel time estimate is similar to the estimate calculated by Shrestha et al. (2002) for recreational fishing in the Brazilian Pantanal, namely $23.43 per hour.

The coefficients of the gender, age, race and income variables were insignificant. As expected the catch rate variable has a positive coefficient and is significant at the 1% level. Fishers who catch more fish per trip are likely to undertake more frequent trips to Rhodes. The sign of the coefficient of the substitute site variable accords with *a priori* expectations. It is positive and statistically significant at the 10% level. This result suggests that those fishers with higher round trip travel times to substitute sites undertake more visits to Rhodes, *ceteris paribus*.

6 Welfare calculations

For the purposes of comparison, welfare estimates were obtained using all four models. The welfare measures calculated in this study apply only to the relevant user population. The recreational demand model, adjusted for zero truncation, count data and over-dispersion, could not be applied to extrapolate welfare measures to non-users because of several reasons. First, the non-user population could not be identified and defined in this study. Second, it was unclear whether non-users have the same demand functions as users (Hellerstein, 1991; Martinez-Espineira & Amoako-Tuffour, 2008). Finally, population values for the parameters in the demand equations were unobtainable (Englin & Shonkwiler, 1995; Martinez-Espineira & Amoako-Tuffour, 2008).

The estimated coefficients of the travel cost covariate for each count data model were used to calculate the welfare measures (see Table 5 below). The average consumer surplus per visit estimates were calculated as the negative inverse of the travel cost coefficient ($-1/\hat{\beta}$) (Creel & Loomis, 1990). This particular method of calculating consumer surplus per visit estimates is possible because a count data model is used (Loomis *et al.*, 2001). Table 5 below presents the estimation results of the welfare measures at the mean of the data. The consumer surplus per angler per trip was calculated to be R13 072 using the regression results of the preferred zero truncated negative binomial model.

Per day consumer surplus estimates were obtained by using the mean length of the visit in days and equals R2 668. The total consumer surplus figures of trout fishing in Rhodes were obtained using the predicted total annual trips by the fisher population. Based on a fisher population of 700, and taking the predicted number of trips per fisher per annum, the aggregate annual number of trips was estimated. The preferred ZTNB model yields a lower estimate of aggregate consumer surplus per annum, namely R18 026 288, compared to the two Poisson models estimated, but yields a slightly higher estimate compared to the standard negative binomial model.

7 Conclusion

The law of South Africa makes provision for maintaining trout habitats. There is good reason for this law – trout fishing makes a significant economic contribution in many regions of South Africa; the North Eastern Cape being one. The trout are legally here and would cost a lot to remove. In addition, there would be WTP foregone as a result of such removal. This paper estimates the foregone recreational value cost as being the order of R18 million. The valuation method employed was the travel cost one. While the welfare estimates calculated in this study are conditional upon the survey sample, they do show the substantial benefit of the trout resource. This benefit value is important from a resource policy point of view. Monetary estimates of the Rhodes trout fishery can assist in fishery management decisions, such as awarding zoning rights for this trout fishery in upper catchments. These estimates can also be of use in comprehending the benefits associated with water quality improvement projects in this area (McConnell and Strand, 1994).

In addition to the recreational value foregone there are also some trickle down benefits to the poor that result from the trout fishing industry in the Rhodes area. Money is injected into the region through the purchase of rights to fish and provision of accommodation and other services. This income, in turn, is used to employ staff to provide the relevant services. This paper did not estimate the proportion of this income reaching the poor, but given the limited scope for economic activity in this region, we think that it has a meaningful beneficial impact.

8 Notes

1. The costs associated with the negative biodiversity impacts of trout have to date not been estimated in South Africa.

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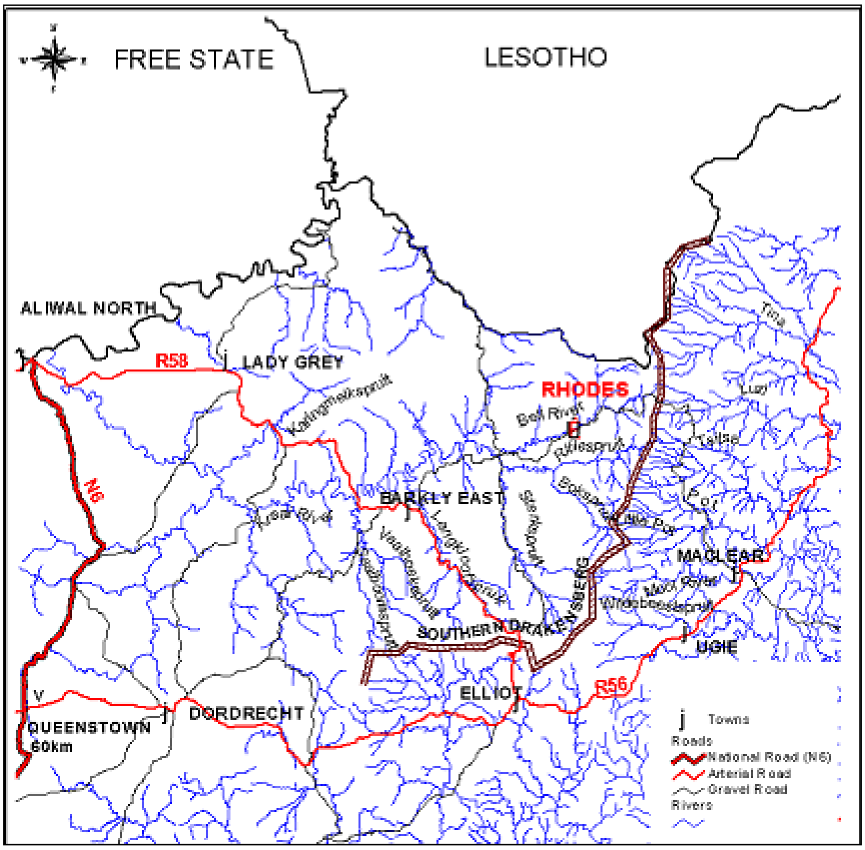
Figure 1. The geographical location of the Rhodes trout fishery



Source: Wild Trout Association (2008)

Table 1. Visitor origin – a comparison of the population and the sample

Visitor Origin	Percentage (%)	
	Population	**Sample**
South Africa by Province		
Gauteng	39	40
Western Cape	19	18
KwaZulu-Natal	15	8.7
North West	1	2.1
Northern Cape	0	3.2
Free State	6	6
Eastern Cape	13	11.6
Elsewhere		
North America	2	2
Europe	4	6.3
Rest of Africa	1	2.1

Table 2. Description of individual travel cost model variables

Variable name	Operational definition	Expected sign
Dependent variable		
Trips/annum	The number of trips per visitor per annum	
Independent variables		
Travel cost	Aggregate travel cost per visitor per visit (Rands)	-
Travel time	Round trip travel time per visitor per visit (Hours)	-
Gender	1= If gender is male 0=Otherwise	+
Race	1=White 0=Otherwise	+
Catch	Aggregate number of fish caught in previous year	+
Age	Age of respondent (Years)	+
Income	Annual after-tax income of respondent (Rands)	+
Substitute	Round trip travel time per visitor to favourite substitute site (Hours)	+

Table 3. Descriptive statistics of the variables used in the recreation demand model

Variable	Obs	Mean	Min	Max
Trips/annum	96	1.6	1	6
Travel cost (Rands)	96	2511.48	137.1571	10749.5
Travel time (Hours)	96	16.85882	2	72
Gender	96	.9176471	0	1
Race	96	.9764706	0	1
Catch	96	35	0	205
Age (Years)	96	41	19	69
Income (Rands)	96	848 020	60 000	1 500 000
Substitute – travel time (Hours)	96	9.27	0.3	30

Table 4. Recreational trout fishing demand model results

	Poisson	∂Poisson /∂X	ES Poisson	∂ESPoisson /∂X	NB	∂NB/∂X	ZTNB	∂ZTNB/∂X
Dependent Variable	**Visits**		**Visits - 1**		**Visits**		**Visits**	
Travel cost	-.0000717	-.0005448	-.000085	-.0005567	-.0000713	-.000541	-.0000765	-.0005689
	(2.74)***		(2.94)***		(1.83)*		(1.83)*	
Travel time	-.0167321	-.1270821	-.0190402	-.1247006	-.0153518	-.116727	-.0159899	-.1189797
	(3.03)***		(3.19)***		(1.74)*		(1.70)*	
Gender	.2481877	1.703771	.2859395	1.667574	.1747044	1.236456	.1808346	1.249398
	(1.63)		(1.74)*		(0.70)		(0.68)	
Race	-.5248461	-5.17779	-.5976927	-5.282014	-.4420009	-4.18240	-.4591314	-4.289239
	(2.39)**		(2.60)***		(1.06)		(1.04)	
Catch	.0024148	.0183404	.0026394	.0172862	.0023467	.0178432	.0023841	.0177398
	(6.07)***		(6.39)***		(2.54)***		(2.42)***	
Age	.0005006	.0038023	.0005919	.0038763	.0014406	.0109532	.001682	.0125159
	(0.13)		(0.15)		(0.23)		(0.25)	
Income	6.59e-08	5.00e-07	7.43e-08	4.86e-07	1.50e-07	1.14e-06	1.66e-07	1.24e-06
	(0.75)		(0.79)		(0.93)		(0.97)	
Substitute	.0088775	.0674256	.0102117	.0668799	.0084292	.0640913	.0089061	.0662699
	(2.99)***		(3.19)***		(1.73)*		(1.72)*	
Constant	2.463032		2.383993		2.354207		2.339797	
	(8.42)***		(7.67)***		(4.42)***		(4.15)***	
Log-L'hood	-281.8367		-291.2399		-241.3746		-239.75641	
Pseudo R^2	0.1153		0.1246		0.04		0.04	
χ^2	73.44***		82.90***		20.09***		19.25***	
AIC	581.6735		600.4798		502.7492		499.5128	
BIC	603.6574		622.4637		527.1757		523.9393	

Absolute value of z statistics in parentheses.

***, ** and * denote significance at 1%, 5%, and 10%, respectively.

Table 5. Welfare calculations

	Poisson	NB	ES Poisson	ZTNB
$\hat{\beta}_{tc}$	-.0000717	-.0000713	-.000085	-.0000765
CS/trip[(1)] (ZAR)	R13 947	R14 025	R11 765	R13 072
CS/day[(2)] (ZAR)	R2 846	R2 862	R2 401	R2 668
Total CS/annum[(3)] (ZAR)	R19 037 655	R17 671 500	R24 541 790	R18 026 288
Predicted trips/annum[(5)]	1.95	1.8	2.98[4]	1.97

(1) CS/trip = (-1/ $\hat{\beta}_{tc}$).

(2) Based on an average number of days per trip of 4.9.

(3) Assuming a population of 700 fly-fishers.

(4) (1.98 + 1) for the ES Poisson – the dependent variable was defined as trip*s* – *1* to account for endogenous stratification and truncation.

(5) Predicted with an average travel cost of ZAR R2 511.