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A Travel Cost Study of Duck Hunting in the Upper South East of South Australia^{*}

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January 2001

^{*} Paper presented at the 45th Annual Conference of the Australian Agricultural and Resource Economics Society, Adelaide. Funding for the research presented in this paper has been provided under the National Wetlands Research and Development Program by Environment Australia and Land and Water Australia. Further information about the research discussed in this paper can be found in the Private and Social Values of Wetlands Research Report series, copies of which are available from the authors and on the web at: apsem.anu.edu.au/staff/jbennettr.htm. We would like to acknowledge the assistance and cooperation of Wetlands and Wildlife, especially Tom Brinkworth, Michael Lewis and Keith Frost. Because this paper reports results of work in progress, it should not be reproduced in part or in whole without the written authorisation of the Research Project Leader, Professor Jeff Bennett.

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Abstract

Wetland protection in the Upper South East (USE) of South Australia yields a range of private and social benefits. The profit motivation for private wetland owners to supply private benefits is clear whilst the provision of purely social benefits by private suppliers has no similar incentive. One potential for the provision of social benefits from private lands arises when a private benefit is jointly supplied with a social benefit. Such is the case of nature-based recreation activities such as duck hunting. In this paper, the results of a study investigating the extent of the benefits enjoyed by duck hunters in the USE are reported. The travel cost method was employed in a survey of those participating in a weekend duck hunt. The extent of the private recreation benefits so estimated is assessed in terms of their potential to stimulate the provision of wetlands for both private and social benefits.

Key words: Travel Cost Method, wetlands, private and social benefits

1 Introduction

Wetlands in the Upper South East of South Australia (USE) generate a range of values to their owners and wider society. Duck hunting is one use that yields values to duck hunters and, in some cases, to wetland owners. In this paper, the values to duck hunters and wetland owners from participating in the year 2000 'Wetlands and Wildlife Organised Shoot' are considered.

In order to consider the benefits of alternative wetland management options within a benefit-cost framework it is necessary to aggregate both monetary and non-monetary values. The focus of this paper is the estimation of the non-monetary values received by duck hunters. These values can then be included in an assessment of the total benefits of wetland protection options for comparison against alternative wetland uses.

Previous research indicates that duck hunting is a significant use of wetlands in the USE region. Duck hunting is undertaken by 39% of wetland owners in the USE on nearly 20,000 hectares of wetlands in the USE region (Whitten and Bennett 1998, 1999). Hence management options that involve a change to the amount of duck hunting available in the USE requires the inclusion of an estimate of the values associated with a benefit cost analysis of duck hunting. In this paper, the values drawn from duck hunting by duck hunters are evaluated.

In Whitten and Bennett (1999) a number of potential management strategies for wetlands in the USE were identified. These strategies would lead to a significant increase in the available waterfowl habitat in the USE region. Some of the additional wetland areas would provide additional areas suitable for waterfowl. To compare the impacts of changes to duck hunting against other impacts of management change they must be considered in terms of society's value for each impact. Economists use dollars as a convenient numeraire of value.

The next section of this report sets out the context within which the valuation takes place including the theoretical framework. Selection of an appropriate valuation methodology and a brief literature review comprise the third section of the paper. The methodology is developed in the fourth section of the paper including development and implementation of the survey instrument. The resulting estimates of values resulting from duck hunting are reported in section five.

2 Method selection

Duck hunting values can be split between pure private values and social values. Purely private values are those held by the owners of the wetlands. These values include both the value to the wetland owner to undertake hunting on the wetlands and the producer surplus from selling hunting rights to others. Monetary estimates of the producer surplus are briefly included within this paper but monetary estimates of private duck hunting values are not.

Social values from duck hunting are the values to other members of the community from undertaking duck hunting in USE wetlands. Part of the social values are sometimes captured by wetland owners by charging a fee for access. The remaining social benefit, after the fee has been subtracted, is termed the consumer surplus.

Similarly, after costs are subtracted from the fee collected for hunting the remainder is termed the producer surplus. The focus of this paper is the estimation of the consumer surplus that arises from duck hunting in the USE.

Nature of the values to be estimated

Non-monetary values can be estimated either by revealed or stated preference techniques. For changes in environmental outcomes to be estimated by revealed preferences, they need to be directly related to actions in the market place. For example, the decision to hunt is directly related to the actions of hunters spending money on petrol, food, hunting fees and other items in order to participate in the Wetlands and Wildlife Organised Shoot.

A second issue is that markets normally cover actions that have already occurred. It is not possible to estimate the potential willingness to pay for hunting via the TCM if hunting does not already occur. Hence, the impacts of a future change that would enhance hunting opportunities cannot be estimated using this methodology without extrapolation. Likewise, the value to duck hunters of retaining the option of hunting in USE wetlands cannot be estimated using the TCM.

Revealed preference methods rely on revelation of the demand for an environmental-good via purchase of marketed goods that are necessary to enjoy the associated environmental good (Turner, Pearce and Bateman 1994). There are two alternative methods for estimating revealed preferences:

1. The hedonic pricing method (HPM) – values environmental goods via their direct impact on market prices. For example, there are a number of wetlands in the USE, some of which are suitable for duck hunting, and some of which are not. By comparing the price of wetlands suitable for duck hunting against those that are not the value of the duck hunting attribute of wetlands to wetland owners could be estimated.¹
2. The travel cost method (TCM) – values environmental goods via the assumption “that the incurred costs of visiting a site in some way reflect the recreational value of that site” (Turner, Pearce and Bateman 1994, p. 116). By estimating this relationship, a value for the recreational activity can be estimated.

The incurred costs of duck hunting are revealed via the purchase of marketed goods including petrol and transport costs, food, hunting fees and equipment. Hence, the TCM method is suitable to the estimation of consumer surplus from hunting USE. The HPM is only suitable to estimate producer surplus in the USE region because the rights to hunt must be purchased (or at least granted) by wetland owners. In addition, the relatively small number of owners of wetlands suitable for duck hunting (and hence the very small number of land transactions) in combination with the bundle of additional characteristics of the land bundle precludes use of the HPM.

The TCM is conceptually relatively simple and easy to implement. The costs of collecting sufficient data to apply the model make the technique especially attractive in the context of the USE region. The TCM is a well established technique that has yielded relatively consistent and reliable results (Bennett 1995). A number studies

¹ Other factors such as the range of alternative uses of wetlands may also have to be included in such an analysis.

(particularly in the US) have used the TCM to generate estimates of hunting and fishing values including; Cooper and Loomis (1993), Cooper 2000 and Offenbach and Goodwin (1994). Cooper and Loomis (1993) estimated a willingness to pay of \$15.62 (\$US 1993) and \$26.21 (\$US 1993) per waterfowl hunting trip to National Wildlife Refuges in the San Joaquin Valley in California. Offenbach and Goodwin (1994) estimate a willingness to pay of \$160.79 and \$176.55 per hunting trip for hunting trips (waterfowl and other game) in Kansas. Cooper (2000) uses alternative techniques to re-analyse the Cooper and Loomis (1993) data and produces similar estimates of consumer surplus per hunting trip to the 1993 study.

3 Methodology

Overview of travel cost theory

The TCM is based on the relationship between the recreational service provided (in this case duck hunting) and the purchase and use of goods and services by duck hunters who travel to the site. The “TCM assumes *weak complementarity*” between the expenditure on goods and services and the recreational service (duck hunting) (Hanley and Spash 1993, p. 83). As Hanley and Spash (1993, p. 83) point out, the implication of this assumption is that when consumption expenditure is zero, the marginal utility (and hence consumer surplus) of the good is also zero. Hence, if a decline in wetland quality has no impact on duck hunting there would be no change in the value estimated. A second assumption made under the methodology is that the utility function of duck hunters is separable (Hanley and Spash 1993). That is, the demand for duck hunting can be estimated independently of the demand for other activities (both recreational and non-recreational). Finally, the TCM method makes no distinction between a ‘good’ hunting trip and a ‘bad’ hunting trip. That is, there is no difference in the value estimated if the number of ducks shot per hunter is high or low.

The TCM approach is based on estimation of the relationship between the rate of duck hunting (H) at a site and the costs of travelling to and from that site (TC). This is the trip generator function TGF. The rate of duck hunting (H) is expected to fall as the costs of travelling (TC) increase. Hence, the number of duck hunters per head of population is dependent on the costs of participating in the hunt. Under these assumptions the imposition, or increase, of a participation fee would increase TC and reduce the rate of duck hunting. By simulating the effects of an increase in the participation fee, TC are increased and the impacts on total visitor numbers estimated. That is, a demand curve (the relationship between quantity of duck hunters and price of duck hunting) is derived. The value of hunting to duck hunters (their consumer surplus) is equal to the area under the curve and above the fee charged to participate in duck hunting.

Research design

While the underlying concepts of the TCM are relatively simple, several important methodological issues need to be addressed when applying the model, including:

- Individual versus zonal approach;
- Definition of travel costs;
- Inclusion of multiple purpose trips;
- Treatment of substitute sites; and,
- Statistical analysis issues.

Each of these is briefly discussed in this section.

Individual versus zonal approach

The relationship between the rate of duck hunters and travel costs can be analysed using data on either individual visitors or across a number of population groups referred to as zones. If individual data are used, the number of visits an individual makes during a set time-period is modelled as a function of the costs incurred and other socioeconomic factors. When the zonal approach is used, the visitation rate is defined as the proportion of hunters from the population, in a specific geographic area, per a pre-specified time-period. The TC for each zone is the mean across all people visiting from each zone. Hence, there is an implicit assumption that the people in each zone make the same number of visits at the same average cost. Socio-economic factors for the zone can potentially be used as explanatory factors but the individual level of detail is lost.

A tradeoff arises between the detail that is captured by the individual approach and hence the development of an accurate model and obtaining sufficient variability in the rate of visitation amongst visitors to the site. Because of the relatively short hunting season and the requirements for access to many of the wetlands (as they are on private land) relatively few hunters are able to make repeat visits to USE wetlands. A question was included in the survey to test this hypothesis. Without variability in the individual visit rate the relationship between it and travel cost cannot be identified. Hence, the zonal TCM was used in the USE application.

Definition of travel costs

The concept of travel costs is simple: the costs incurred by hunters in order to participate in duck hunting in the USE. Economic theory refers to this as the opportunity cost – the value of the alternative foregone in order to participate in duck hunting in the USE. Applying the concept is much more difficult. For example, should expenditure on hunting licences be included? Should wear and tear in vehicles used to travel to the site be included? Should the cost of the time taken to travel to and participate in hunting be included, and if so, at what cost? As a first step costs can be split between travel costs and time costs (Bateman 1995). Time costs can be further split between travel time and on-site time.

Bateman (1995) suggests three cost calculation options for travel costs:

- i. Petrol and additional costs only (marginal costs);
- ii. Full car costs (that is petrol, insurance, maintenance costs, etc.) and full additional costs; and,
- iii. Perceived costs as estimated by respondents.

Use of option (ii) will increase the participation costs above (i) and hence increase the resulting consumer surplus estimates. Bateman (1995) reports that the impact may more than double consumer surplus. Bateman indicates the correct cost is that perceived by respondents as pertaining to the visit

Inclusion of the cost of time spent travelling to the hunting site is debated in the TCM literature. Hunters travelling to, and participating in duck hunting are giving up the opportunity to participate in some other activity. Hence, the value of the activity given up should be taken into account. For many visitors, there are not just activities foregone by travelling, there is also some enjoyment in the travelling. Two questions

arise, firstly whether any enjoyment is derived from travelling and secondly the value of any other alternatives foregone. Not including the value of time where it is a cost will substantially reduce the consumer surplus estimates of participating in duck hunting activities. Bateman (1995) suggests that where time costs are thought to be important a sensitivity analysis be conducted using values of 0.25, 0.5, 0.75 and the full wage rate. A question was included in the survey to determine the time spent travelling to the duck-hunting site. Time spent on site is generally assumed to be at zero cost.

Inclusion of multiple purpose trips

A basic assumption of the TCM is that each hunter makes the trip solely to hunt ducks in the USE. This may not be the case, particularly for hunters who have travelled large distances. If there are hunters who have travelled for multiple purposes their costs need to be apportioned between the different activities undertaken along the way. The majority of hunters are hypothesised to be travelling only to participate in duck hunting in the USE. This is because duck hunting is primarily a weekend recreational activity and because the ducks that are taken need to be frozen relatively quickly. A question was included in the survey to determine the proportion of hunters travelling for multiple purposes and the relative importance of participating in duck hunting to the trip.

Treatment of substitute sites

The presence of substitute sites can impact on visitor demand via their travel cost (or price), their entry fees and their relative quality (Bateman 1995). Such variables are rarely included due to the difficulty of collecting and including such data. Non-inclusion of substitute sites can lead to either over or under-estimation of the consumer surplus depending on their relationships to each other geographically and of relative quality (Connolly and Price 1991, Price et.al. 1986). A question was included in the survey to determine whether the issue of substitute sites is a problem.

Statistical analysis issues

Two major statistical issues arise when using the TCM:

- Data is restricted to whole numbers (you can't have a half visitor) and only those who actually visit a site; and,
- What functional form the 'trip-generation function' (TGF) should take.

The dependent variable of the TGF is both truncated and censored (Hanley and Spash 1993). It is truncated because only hunters who actually participate in duck hunting in the USE are surveyed. Furthermore, hunters are only recorded at the survey site, during the survey period. Hence, the preferences of duck hunters at other sites and other times within the hunting season are not recorded. The dependent variable is censored because the minimum visit that can be recorded is one (you cannot get half a visit). A strict conclusion is that ordinary least squares (OLS) regressions should not be used to analyse the data, rather maximum likelihood (ML) methods should be used (Bateman 1995). However, the literature is mixed on whether ML produces more accurate results. Smith and Desvousges (1986) and Garrod and Willis (1991) found that use of ML and OLS can lead to significantly different results. But Kling (1987, 1988) and Smith (1988) suggest that OLS may produce more accurate consumer surplus estimates.

The TGF can be specified as a wide range of functional forms including linear, quadratic, semi-log and double-log. *A priori* none of these forms is superior to the others (Bateman 1995). However, the choice of functional form is important as it can have a large impact on the consumer surplus estimates. For example, Hanley (1989) reports consumer surplus estimates of between £0.32 (quadratic form) and £15.13 (double-log form). R-squared can be used as a basis between semi-log and double-log models (providing the dependent variable is logged in both), but not between log models and quadratic models, nor between models with differing dependent variables. Willis and Garrod (1991) suggest selecting the model which best predicts visitor numbers across sites. Both these methods will be used to help select models in this paper.

Survey design

A TCM study of duck hunting in the USE region would ideally involve the collection of data from all hunters over a complete hunting season. Data collection over several seasons would be required to reduce the impact of individual hunting seasons on the overall visitation patterns. For example, 2000 was the fifth year in a succession of dry years, and while the quality of hunting was an improvement on previous years it was not as good as the long term average. The reduced quality is reflected in the number of hunters who participate in duck hunting in the USE during the year 2000 open season. Unfortunately, collection of data from all hunters who undertook duck hunting in the USE during the year 2000 was not practicable. However, by far the largest number of duck hunters (and probably nearly 50 percent of those undertaking hunting in the USE during the 2000 open season) participate in the annual 'Wetlands and Wildlife Organised Shoot'. A survey was therefore designed for implementation at the year 2000 event. The questionnaire would be distributed to all duck hunters as part of the registration procedure at the 'Wetlands and Wildlife Organised Shoot'. Completed questionnaires would then be collected either immediately or prior to hunters leaving the event.

The questionnaire consisted of the following sections:

- A short preamble including who is collecting the information and use of the information;
- Seven questions gathering data required for a TCM analysis;
- A short section thanking respondents and indicating who to contact for additional information; and,
- Opportunity for additional feedback.

The questionnaire was based on Bennett's (1995) suggested simplified format.²

The questionnaire was designed to collect the following information:

1. Respondents usual place of residence (Question 1).
2. Method of transport (own transport, with friends or other) (Question 2).
3. The number of people they had travelled with (Question 3).
4. The range of substitute hunting areas accessed in the last 12 months (Question 3).
5. Self estimated range of costs of participating in the event (Question 5).
6. How long it took to travel to the event (Question 6).
7. Whether participation in duck hunting was the sole reason for the trip, and its relative importance if it was not (Questions 7 and 8).

² Copies of the questionnaire are available from the authors on request.

Survey implementation

The population to be surveyed is individuals who undertake duck hunting in the USE region (and theoretically those who would potentially hunt in the region). The ‘Wetlands and Wildlife Organised Shoot’ is the largest annual shoot in the region and has historically attracted over 1000 duck hunters during good seasons. As indicated above, the survey was designed to be very brief and completed alongside other registration procedures at the shoot. Duck hunters were given the questionnaire on registering to shoot, some surveys were completed and collected immediately while others were collected over the duration of the shoot. Nearly 300 hunters attended the year 2000 ‘Wetlands and Wildlife Organised Shoot’. As some groups were registered by a single group member some hunters may not have received the survey. One hundred and ninety three responses were received for a response rate of approximately 65 percent across all hunters attending the shoot.

4 Results

Data preparation

The zonal TCM requires estimation of the relationship between the costs of travelling to the shoot and the proportion of the population from each zone travelling to the shoot (the TGF). The goal in combining respondents into zones is to establish composite zones containing sufficient respondents, but which are also relatively homogenous in terms of distance from the shoot and socioeconomic makeup. Ideally, each zone should also have a minimum of 30 respondents. A pragmatic response means that trade-offs need to be made between these goals – especially between homogeneity and sample size. The final zones used for the USE duck hunting TCM are shown in Table 1. In

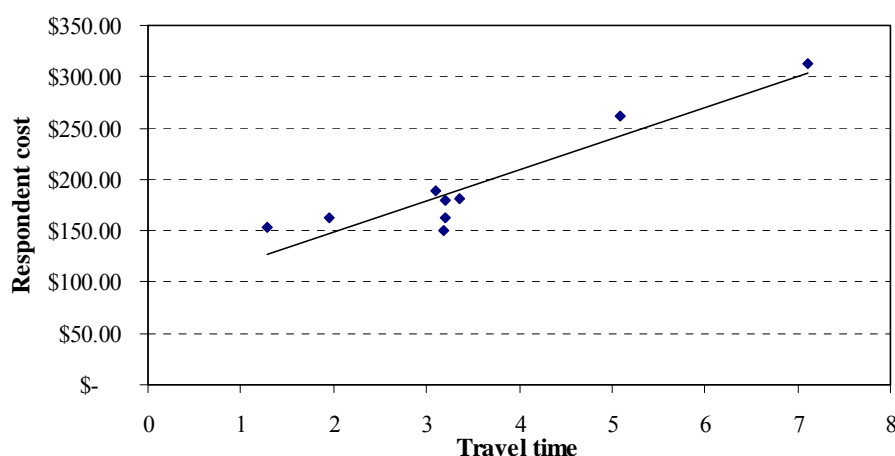
Figure 1, the travel time is plotted against the cost of attending the hunt.

Table 1: USE duck hunting TCM zones

Zone	Male population over 15 years [#]	Number of hunters	Mean cost of respondents	Mean travel time*
1. Local	2845	24	\$152.92	1.28
2. Naracoorte and districts (also includes Murray Bridge)	19789	39	\$162.31	1.94
3. Adelaide	428248	27	\$180.19	3.20
4. LSE remainder	12577	19	\$162.11	3.21
5. Horsham and district	9893	28	\$189.64	3.10
6. Central and Northern Victoria	125805	18	\$261.67	5.08
7. Melbourne and surrounds	1297696	14	\$312.86	7.10
8. North Wimmera	9290	11	\$180.91	3.36
9. Hamilton and districts	14019	13	\$150.00	3.19

* Travel time is in hours and fractions of hours.

[#] The male population is used as only male shooters participate in the ‘Wetlands and Wildlife Organised Shoot’.

Figure 1: Duck hunter travel time and cost*Travel costs*

Respondents were asked to provide an estimate of the monetary cost of attending the hunt. The respondent estimate is an estimate of the marginal monetary costs of attending the hunt. The respondent estimate does not include the opportunity costs of attending the hunt. On-site time is assumed to generate a positive utility and is not further considered. As respondents were also asked to include an estimate of travel time, a proxy for the opportunity cost of travel time can be included. The proxy can be used to test the sensitivity of the consumer surplus estimates to alternative values of time as per Bateman (1995). The time values used were 0.25, 0.5, 0.75 and full value of time estimated using the mean male weekly wage (in February 2000 from ABS 6301.0) divided by the mean number of hours worked by males in 1998-99 (ABS 2001). The hourly wage rate calculated using this methodology was \$19.09 per hour.

A question was included in the survey to determine the proportion of multiple purpose trips and the relative importance of participating in the duck hunt to the trip, reported in Table 2. Table 2 shows that only three hunters indicated that participating in the hunt was not either the sole purpose of the trip or very important to the trip. Hence, the data were not adjusted for multiple purpose trips, as it is considered unlikely that the three observation would bias the results.

Table 2: Relative importance of participating in duck hunting to trip

Zone	Sole purpose	Very Important	Moderately important	Slightly important
1. Local	23	-	1	-
2. Naracoorte and districts (also includes Murray Bridge)	34	5	-	-
3. Adelaide	20	7	-	-
4. LSE remainder	14	5	-	-
5. Horsham and district	27	1	-	-
6. Central and Northern Victoria	17	1	-	-
7. Melbourne and surrounds	12	1	-	1
8. North Wimmera	11	-	-	-
9. Hamilton and districts	11	1	-	-

Note: There were two non-responses to this question.

Visitation rate

The dependent variable in the TGF is the number of duck hunters per head of population from each zone. Because the 'Wetlands and Wildlife Organised Shoot' is a male only event the population for the analysis is the population of males over 15 in each zone. The population for each zone was calculated using the ABS Census data from the 1996 census (ABS 2001).

The travel cost relationship

The TGF is estimated by regressing the visitation rate against the mean travel cost for each zone. Hence, the regression involved one observation on each zone for a total of nine observations. Three alternative functional forms were investigated:

- a) Semi-log dependent: $\log(\text{visit rate}) = a + b \text{ travel cost}$
- b) Semi-log independent: $\text{visit rate} = a + b \log(\text{travel cost})$
- c) Double log: $\log(\text{visit rate}) = a + b \log(\text{travel cost})$

Decisions between (a) and (c) can be made using model validity, R-squared and accuracy of predicted hunter numbers. Only model validity and accuracy of predicted hunter numbers can be used to decide between (b) and (a) or (c).

Regressions were undertaken using OLS. Predicted hunter numbers from all models indicated that the visit rate from Adelaide was substantially different from the other zones and was extremely poorly predicted (over one hundred hunters versus just 17 in reality). This was possibly due to differences in population tastes between capital cities and rural areas. Because of the large difference, Adelaide is also acting as an outlier on remaining predictions. A dummy variable for Adelaide was therefore included in the model to eliminate this effect.

A dependent variable semi-log model (model (a)) was selected due to superior model validity over model (b) and superior R-squared and predictive accuracy over model (c). The final model was:

$$\log(\text{visit rate}) = a + b \text{ travel cost} + c \text{ Adelaide dummy}$$

With no time costs included the estimated TGF is:

$$\log(\text{visit rate}) = -0.830 - 0.323E-1 \text{ travel cost} - 3.027 \text{ Adelaide dummy}$$

$$(1.134) \quad (0.555E-2) \quad (0.926)$$

Note: numbers in brackets are standard errors

Other modelling issues

The potential impact of substitutes was gauged by asking to indicate where, and how many times, they had been hunting the previous twelve months. Several respondents reported duck hunting up to 50 times in Victoria and 30 times in New South Wales. These numbers seem to be too high, particularly as the Victorian open season lasted from March 18 to June 12 (87 days) and New South Wales had no open season only allowing shooting for pest control purposes. Hence, a potentially better indicator of the substitute areas available to duck hunters is the proportion of hunters in each zone that hunt in each area as shown in Table 3. A majority of hunters from all zones except two (LSE remainder and Melbourne and surrounds) hunted in the USE in the last twelve months. For many hunters this would have been the 1999 'Wetlands and Wildlife Organised Shoot'.

Table 3: Proportion of hunters hunting in substitute areas by zone

Zone	Proportion of hunters hunting in each area in last 12 months						
	USE	LSE	Lower SA Murray [#]	Upper SA Murray [#]	Victoria	Other	Substitutes
1.	91.7%	4.2%	8.3%	0.0%	4.2%	4.2%	0
2.	74.4%	23.1%	2.6%	2.6%	10.3%	20.5%	0
3.	51.9%	3.7%	29.6%	7.4%	7.4%	11.1%	0
4.	31.6%	47.4%	10.5%	15.8%	52.6%	10.5%	2
5.	46.4%	28.6%	3.6%	3.6%	78.6%	35.7%	2
6.	61.1%	5.6%	0.0%	0.0%	100.0%	55.6%	2
7.	28.6%	7.1%	0.0%	0.0%	71.4%	28.6%	1
8.	81.8%	27.3%	0.0%	0.0%	90.9%	63.6%	2
9.	53.8%	7.7%	0.0%	0.0%	84.6%	23.1%	1

[#] Lower SA Murray is the Murray River and floodplain below Murray Bridge including lakes Alexandrina and Albert. Likewise, the Upper SA Murray is the same above Murray Bridge. Substitutes are defined as more than one third of hunters from the zone have hunted in that area in the previous twelve months.

Victorian hunters had a larger number of substitute sites. All hunters in central and western Victoria have at least two substitute sites. The substitute variable shown in Table 3 was tried within the model in an attempt to include the affects of substitutes. The variable was insignificant and showed the incorrect sign. This is potentially because the duck hunting open season in South Australia and Victoria overlap rather than occurring at the same time. The South Australian open season opened on February 12, 2000 while the Victorian open season did not open until March 18. As indicated NSW did not have an open season but duck shooting was allowed under permit for pest control purposes. Hence, the Victorian substitutes in Table 3 were not available at the time of the shoot confounding their impact on the model.

Mode of travel also potentially affects the visit rate. Hunters travelling as a group presumably lower their costs of attendance. The proportion of hunters in each group who travelled as part of a group were also included as an explanatory variable, however the coefficient was insignificant with an incorrect sign. It is likely that the impacts of the variable were incorporated in the self-estimated travel costs.

The demand function

The TGF is used to simulate the number of hunters from each zone that would attend the 'Wetlands and Wildlife Organised Shoot' under different pricing conditions. That is, the TGF can be used to derive a demand curve for duck hunting. The simulation exercise is undertaken by predicting the number of hunters from each zone, at the original estimated cost of that zone. A fee increase is simulated by raising costs by \$5 and the process repeated. This step is repeated for simulated increases of up to \$100. Respondents are assumed to treat entry fees in the same way as other costs of participation. The total number of hunters is then calculated by summing the predicted numbers from each zone at each price level. The summed numbers of hunters at each price level is the demand curve for hunting at various price levels. Total hunter numbers predicted at no cost increase will most likely differ from actual numbers because they are based on the regression equation. This process must also be repeated for the alternative models used to test the sensitivity to cost of travel time.

In order to estimate the demand curve, the hypothetical fee increase is regressed against the estimated number of hunters. A similar choice of functional forms is

available to those tried for the TGF. A semi-log model form again proved to possess the best model validity. The model used was:

$$\text{Log hunting fee increase} = a + b \text{ hunters}$$

The base model demand curve is plotted in Figure 2. The demand curve equations for the base model and travel time cost sensitivity models are reported in Table 4.

Figure 2: Demand for duck hunting in the USE of SA

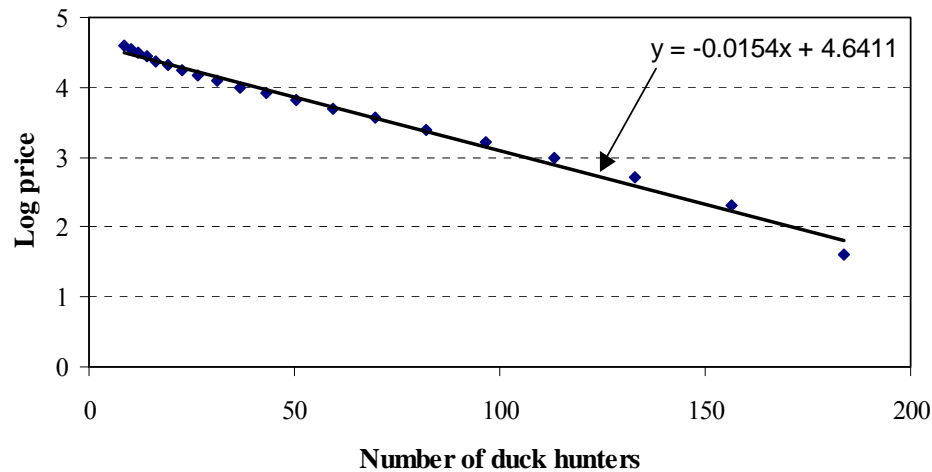


Table 4: Demand curve equations for duck hunting in the USE

Coefficients	Models estimated using OLS				
	Base	0.25 cost	0.5 cost	0.75 cost	Full cost
Constant	4.641 (0.272E-1)	4.737 (0.312E-1)	4.836 (0.376E-1)	4.938 (0.455E-1)	5.041 (0.541E-1)
Quantity	-0.155E-1 (0.348E-3)	-0.156E-1 (0.377E-3)	-0.157E-1 (0.433E-3)	-0.158E-1 (0.497E-3)	-0.159E-1 (0.564E-3)
R ²	0.991	0.990	0.986	0.982	0.978
F	1972.595	1702.675	1311.077	1007.630	800.439

Note: Bracketed numbers are standard errors

Consumers' surplus estimation

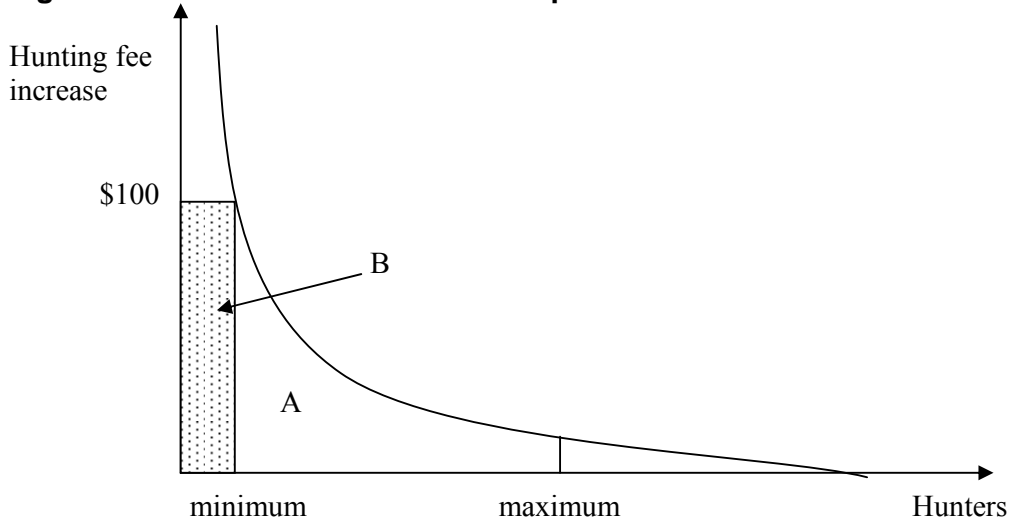
The demand curve estimated above can be used to calculate the consumers' surplus enjoyed by duck hunters participating in the 'Wetlands and Wildlife Organised Shoot' in 2000. The consumers' surplus is the area under the demand curve at the current level of hunting fees.³

In the case of a semi-log function, the area under the demand curve is calculated by integrating the function between an upper and lower point of truncation (area A in Figure 3), plus the area between the upper price and minimum number of hunters (area B in Figure 3). Because a semi-log function is asymptotic to the price axis, the area under the demand curve would be infinite if no truncation was performed. The upper point of truncation is the current number of hunters. The lower point is arbitrarily set at the level of visits that corresponds with a \$100 increase in the current

³ It is the area at the current level of fees because fees were specifically included in the self-estimated travel costs of respondents. If fees were not included in these estimates then the consumers' surplus would be the area under the demand curve but above the current level of fees.

level of fees. At this level, most of the responsiveness to the simulated changes in the participation fee has been exhausted.

Figure 3: Calculation of consumer surplus



The integration process is set out below:

$$\text{Log } F = a + b H$$

$$F = e^a * e^{b H}$$

Hence: $\int F d H = e^a / b * [e^{b H}]_{\text{lower limit}}^{\text{upper limit}}$

Where: a and b are the regression parameters;
e is 2.718;
F is the hypothetical increase in hunting fees; and,
H is the number of hunters.

Therefore the consumers' surplus for the base model is:

$$\begin{aligned} CS &= e^{4.641} / -0.155E-1 * [e^{-0.155E-1 * 193} - e^{-0.155E-1 * 9}] + 9 * 100 \\ &= \$6,398.07 \end{aligned}$$

The consumers' surplus calculated represents that of the 193 respondents to the questionnaire. The per visit consumers' surplus is \$27.46. This is the total consumers' surplus divided by the number of respondents. To estimate the total consumers surplus for the 'Wetlands and Wildlife Organised Shoot', the per visit consumers' surplus is multiplied by the total number of participants (300). Hence, the total consumers' surplus for the 2000 shoot is \$8,237.86. Similarly, the consumers' surplus can be extrapolated across the all duck hunting undertaken in the USE (assuming similar demand conditions and hunting quality).

To estimate the sensitivity of the model to inclusion of costs for travel time, the above calculations are repeated for the alternative models. The results of these are reported in Table 5. There is a large difference between estimates. The full cost estimate is 62 percent larger than the base model estimate. The difference between the models

shows the importance of the treatment of the costs of travel time to consumers' surplus estimates.

Table 5: Sensitivity of estimates to inclusion of cost of travel time

	Base	0.25 cost	0.5 cost	0.75 cost	Full cost
Maximum	193	193	193	193	193
Minimum	9	12	16	20	24
Total CS	\$6,398	\$6,920	\$7,471	\$8,023	\$8,567
Individual CS	\$27.46	\$35.86	\$38.71	\$41.57	\$44.39

Calculation of a net present value of duck hunting

The final step in the analysis of consumers surplus is estimation of a net present value of hunting benefits that could be expected from wetlands in the USE. To calculate the NPV, the consumers surplus is expressed as an annuity that would be received in perpetuity. The present value of the annuity is multiplied by the inverse of the selected discount rate to estimate the NPV. A base estimate of the NPV is shown in Table 6.

Two issues need to be clarified prior to estimating an NPV. Firstly, the quality of the year 2000 duck hunting season was worse than historical averages and this will have reduced the number of hunters attending the 'Wetlands and Wildlife Organised Shoot'. Hence, the appropriate NPV for the shoot alone will be higher than that estimated using year 2000 numbers. Wetlands and Wildlife provided data on the number of shooters attending the Organised shoot over the last thirteen years. These numbers were used to estimate an average number of hunters attending, along with an upper and lower number of hunters to test the sensitivity of this assumption. NPV estimates are provided in Table 6.

Secondly, some hunters make more than one hunting trip to the USE. For example, 69 respondents (35.8 percent) made more than one trip to the USE. On average, these respondents made 3.78 hunting trips in USE wetlands in the previous 12 months, and were dominated by respondents that living closer to the wetlands. Assuming similar travel costs and quality of the hunting experience the value hunting trips can also be included. This assumption is not as unlikely as it may seem, as participants in the 'Wetlands and Wildlife Organised Shoot' do not know which of several wetlands they will be allotted to hunt on. Each of these wetlands may also be some distance from the centralised meeting point. The final column of Table 6 shows estimates adjusted using the above figures (that is, 35.8 percent of respondents make 3.78 trips, and the remainder one). These estimates could be sensitivity tested but are not in this paper to maintain simplicity.

Table 6: Estimates of NPV for hunting ducks in the USE

Model used	2000 shoot	Long term average	Upper sensitivity	Lower sensitivity	Total USE estimate
Base model	\$116,104	\$387,013	\$503,117	\$135,455	\$910,642
50% cost travel time	\$163,663	\$545,542	\$709,205	\$190,940	\$1,283,661
Full cost travel time	\$187,682	\$625,608	\$813,290	\$218,963	\$1,472,055
Number of hunters	300	1000	1300	350	2353

Note: The long-term number of hunters is estimated at 1000. This is below the long-term average, however the total number of hunting licences has also declined over this period. The upper and lower hunter numbers are the 2nd highest and lowest numbers of hunters in the last five years. NPVs calculated over 25 years using a 5 percent discount rate

5 Conclusions

The aim in this paper has been to present estimates of the values generated by duck hunting in the USE of South Australia. These values were estimated using a travel-cost survey of participants in the year 2000 'Wetlands and Wildlife Organised Shoot'. The use of the TCM facilitates estimation of the consumers' surplus associated with participating in the shoot. This consumers' surplus can be extrapolated (under certain assumptions) to all duck hunting in the USE.

Duck hunters participating in the shoot derived an average consumer surplus of between \$27.46 and \$44.39. The variation is due to a range of alternative values that could be placed on time spent travelling to the shoot. These values generate a net benefit of between \$8,238 and \$13,317 for the year 2000 event. Extrapolating these estimates across all years generates a base NPV estimate of \$387,013. Further extrapolation across duck hunting in all USE wetlands produces a base NPV estimate of \$910,642.

The estimates that are reported in this paper comprise a portion of the non-monetary values generated to the duck hunting community. These values will be incorporated with other estimates of monetary and non-monetary benefits and costs in a benefit-cost framework. This framework will be used to assess the likely net benefits (or costs) of undertaking management changes in USE wetlands. These values can also be traded off against the non-market costs that duck hunting imposes on some members of the wider community. These costs were estimated using a choice modelling survey and are reported in Whitten and Bennett (2001).

The producer surplus should also be incorporated within any benefit-cost use of the results. Hunters are charged \$20 to participate in the 'Wetlands and Wildlife Organised Shoot'. This revenue generates a present value of \$280,000 dollars towards wetland management in the region. If considering an economic cost analysis the additional costs imposed on wetland management by running the shoot should also be incorporated. These additional costs are minimal and include maintenance of access points, direct management of the hunt, and catering associated with the hunt.

However, a benefit-cost analysis is far from straightforward because it involves a three-way trade-off. Firstly, wetland owners allow hunters to generate consumers surplus by participating in hunting in wetland areas. The same hunting action generates a cost to the wider community via their distress over the killing of waterfowl. Secondly, wetland owners trade-off the costs maintaining wetlands against the benefits they are able to generate from wetlands (in part via capture of the consumer surplus generated by hunters – who may include the wetland owner). Finally, maintenance of wetland habitat generates other social benefits to the community such as maintenance of habitat and protection of endangered species that must also be traded-off against the costs of allowing hunting. The degree to which hunting facilitates generation of benefits from wetlands against its potential biophysical costs (or benefits) to species in wetlands is the unknown link.

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