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PRIVATE AND SOCIAL VALUES OF WETLANDS RESEARCH REPORTS

A travel cost study of duck hunting in the Upper South East of South Australia

By S.M. Whitten and J.W. Bennett

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Abstract

Wetlands in the Upper South East (USE) of South Australia yield a range of values to their owners and to the wider community. One such value is that generated by duck hunting in the region. Wetland owners receive private benefits from hunting fees, while hunters gain a non-monetary consumers' surplus. The non-monetary benefits received by duck hunters are the focus of this Research Report. A 'travel cost' survey of duck hunters participating in an organised shoot held by Wetlands and Wildlife in February 2000 was undertaken. 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.

About the Private and Social Values of Wetlands Research Project

Wetlands generate values enjoyed by their owners and the wider community. Individual wetland owners manage wetlands for income generating purposes such as grazing and in some cases hunting and eco-tourism. These are private values from wetlands. Private owners, through the way they manage their wetlands, can change the availability of their wetlands for recreation or wildlife habitat that the community enjoys. These are social or community values of wetlands. In this project, the trade-offs wetland owners and the community face when making decisions about how to use their wetlands are being examined. This information will help the community to achieve better use of wetland resources on private lands.

There are five main steps to achieving our main goal of better wetland resource use on private land:

1. Model the changes in the physical attributes of wetlands resulting from alternative uses (biophysical modelling);
2. Estimate the community's value of the commercial (private) and non-market (social) outputs of alternative wetland uses (economic valuation);
3. Incorporate the value estimates into the biological modelling framework to establish the value trade-offs of alternative uses (bio-economic modelling);
4. Investigate alternative institutional frameworks that would give private wetland owners incentives to manage their wetlands in ways which maximise net community benefit; and,
5. Generalise the research findings to wetlands Australia wide.

Two case studies in differing locations with differing mixes of alternative wetland uses and wetland values have been selected for analysis:

- The Upper South East (USE) of South Australia; and,
- The Murrumbidgee River floodplain between Wagga Wagga and Hay in New South Wales

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. Hence, the benefits received from duck hunting need to be included in any benefit-cost analysis of alternative options for wetland management. In this Research Report, the values to duck hunters and wetland owners from participating in the year 2000 'Wetlands and Wildlife Organised Shoot' are analysed.

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

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. Section five concludes with a brief evaluation of the monetary benefits drawn by wetland owners. The paper is concluded by setting the estimates into the next phases of the Private and Social Values of Wetlands Research Project.

2 Background

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 (Research Report 2). Hence, a benefit cost assessment of 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 duck hunting. In this Research Report, the values drawn from duck hunting by duck hunters (including wetland owners) are evaluated. Duck hunting values drawn by the wider community (positive or negative) are considered in Research Report 8.

In Research Report 3 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 be suitable for waterfowl. The indicative additional areas of healthy wetlands and number of additional ducks that would become available for hunting are shown in Table 1.

Table 1: Difference between 'business as usual' and alternative strategies in the USE

Descriptive Attributes	**Unit**	**Wetland retention**	**Pro-wetlands**	**Wetlands and remnants**	**Cumulative farm forestry**	**Farm forestry alone**
Healthy wetlands	ha	12,633	25,267	28,425	31,584	3158
	(%)	*(28.6)*	*(57.1)*	*(64.3)*	*(71.4)*	*(7.1)*
Degraded wetlands	ha	-12,633	-12,633	-15,792	-18,950	-3158
	(%)	*(-66.7)*	*(-66.7)*	*(-83.3)*	*(-100.0)*	*(-16.7)*
Waterbird hunting	No.	1440	2630	2980	3320	360
	(%)	*(24.2)*	*(44.1)*	*(50.0)*	*(55.7)*	*(6.0)*

Note: The number of ducks hunted is based on the number of trips undertaken by hunters and hence is not affected by bag limits.

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. Estimation of the values to duck hunters from hunting in the wetlands forms part of the 'Economic Modelling' phase of the 'Private and Social Values of Wetlands Research Project'.

The economic modelling component refers to the analysis of the change in community well being that would result from each potential management strategy. The concept of economic modelling is based on the theory of economic surplus. An economic surplus occurs where either the producer or consumer receives a net benefit. That is, a consumers' surplus exists where consumers receive benefits in excess of their costs (monetary and non-monetary) while a producers' surplus exists where the benefits of production (in terms of sale of goods and services and any other benefits) exceeds all costs of production (monetary and non-monetary).

To simplify the economic modelling the values to be estimated are divided into monetary and non-monetary values. Monetary values are estimated within the market place. Non-monetary values are more difficult to estimate. Furthermore, not all values can be strictly divided into monetary or non-monetary values. In the case of duck hunting the producers' surplus may be monetary while the consumers' surplus is non-monetary. Hence some values (for example tourism) are part private and monetary (producers' surplus from accommodation etc.) and part public and non-monetary (consumers' surplus from wetland visitation). The physical changes in the numbers of ducks hunted under alternative wetland management strategies (indicated in Table 1) generate changes in values that are part monetary (producers' surplus from the hunting fee) and part non-monetary (consumers' surplus from hunting). The next section focuses on the selection of an appropriate methodology for estimating dollar values for the non-monetary consumers' surplus.

3 Method selection

3.1 Nature of the values to be estimated

Non-monetary values can be estimated either by revealed or stated preference techniques (see Box 1 for more information). 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.

Box 1: Revealed and stated preferences

Revealed preferences: Demand for the environmental outcome is *revealed* via behaviour in a market necessary to enjoy the environmental good (Turner, Pearce and Bateman 1994). For example, the value of a wetland view can be estimated by comparing the price of houses with a view to similarly located houses with no view of the wetland. Another example of revealed preferences involves the analysis of the monetary costs incurred by visitors to a wetland to estimate the value of wetland-based recreation.

Stated preferences: Demand for the environmental outcome is estimated via a survey of the community in which respondents *state* their preference about environmental outcomes. For example, the value of a change in an environmental outcome is estimated by asking a sample of the community about their willingness to pay to achieve a specified increase in waterbird breeding events, or to prevent a specified reduction in waterbird breeding events.

The use of revealed preferences is also limited to cases where actions have already occurred. For instance, it is not possible to estimate the potential willingness to pay for hunting from revealed preferences 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.

3.2 Revealed preference methods

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 of the wetlands as a site for recreational activity can be estimated.

The incurred costs of duck hunting are revealed via the purchase of marketed goods including petrol and other transport costs, food, hunting fees and equipment. Hence, the TCM method is suitable to the estimation of consumers' surplus from hunting in the USE. The HPM is only suitable to estimate producers' 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 the use of the HPM.

The TCM is a well established technique that has yielded relatively consistent and reliable results (Bennett 1995). The costs of collecting sufficient data to apply the model make the technique especially attractive in the context of the USE region. A number studies (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 consumers' surplus per hunting trip to the original estimates.

4 Methodology

In the previous Section, the most appropriate method for estimating duck hunting values in the USE was selected. In this section, the application of TCM to the USE is described. The major components in the application are research design, survey design and survey implementation.

4.1 Overview of travel cost theory

The TCM is based on the estimation of 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). The implication of this assumption is that when consumption expenditure is zero, the marginal utility (and hence consumers' surplus) of the good is also zero. In other words, the consumers' surplus of the furthest distant wetland visitor approaches zero because the costs of the visit almost equal the benefits enjoyed from the trip. People living further away, with higher costs, do not visit because they would not enjoy any surplus. 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 used 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. This is because the TCM methodology used is based on hunters' expectations of trip quality. More complicated individual and multi-site approaches can account for these factors (as discussed in section 4.2).

The TCM approach is based on the estimation of the relationship between the rate of participation in duck hunting (H) at a site and individual costs. That is, the relationship between the number of people hunting per head of population, and the costs of travelling to and from that site (TC). This is the trip generation function (TGF):

[1] See Fraser and Spencer (1998) for an example involving the valuation of a coastal view.

$$H = f(TC)$$

The rate of participation in duck hunting (H) is expected to fall as the costs of travelling, potentially including the travel time, (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 participation in 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 consumers' surplus) is equal to the area under the curve and above the fee charged to participate in duck hunting.

4.2 Research design

Several important methodological issues need to be addressed when applying the TCM, 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 frequency of duck hunting 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. Other factors that could explain the number of visits (such as income, age, life cycle stage and educational background) can also be included within the model.

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 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. The zonal approach generalises across the geographically defined zones and therefore cannot take account of the individual socioeconomic factors that can be incorporated in the individual approach. However, socioeconomic factors for the zone can potentially be used as explanatory factors.

A trade-off 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 this application.

Definition of travel costs

Travel costs are defined as 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 TC concept involves the consideration of a number of questions:

- 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 costs above (i) and hence increase the resulting consumers' surplus estimates. Bateman (1995) reports that the impact may more than double consumers' surplus. Bateman argues that the correct cost is that perceived by respondents as pertaining to the visit. For example, respondents may perceive daily insurance and maintenance costs as sunk costs that are not traded-off against alternative uses. Option (i) or (iii) are considered superior to (ii) (Bateman 1995). This is because (i) and (iii) are estimates of the marginal costs that hunters perceive and consider when undertaking a visit. Options (i) and (iii) refer to a comparison between marginal costs and the marginal utility from participation.

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 consumers' surplus estimates of participating in duck hunting activities. One approach used by Cesario and Knetsch (1976) is to include time spent travelling at one-third of the average hourly wage rate. Bateman (1995) suggests that where time costs are though 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 exogenously determined. At the margin, time spent on-site is expected to generate utility equal to that from alternative activities. Hence, time spent on-site is treated as having no impact on the consumers' surplus estimates.

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 long 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 consumers' surplus depending on their relationships to each other geographically and of relative quality (Bateman 1995). A number of solutions to the substitute problem have been suggested. However, all still suffer from significant problems. Hence, the issue of substitute sites remains a potential weakness of applying the TCM to duck hunting in the USE. A question was included in the survey to determine whether the issue of substitute sites is a problem.

Statistical analysis issues

Three statistical issues arise when using the TCM:

- Data are restricted to whole numbers (you can't have a half visitor) and involve only those who actually visit a site;
- The functional form of the 'trip-generation function' (TGF); and,
- The weighting of the model.

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 Desvouges (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 consumers' surplus estimates. The more recent paper by Cooper and Loomis (1993) used Poisson type estimators for count data for a zonal study of waterfowl hunting in the San Joaquin Valley National Refuge.

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 consumers' surplus estimates. For example, Hanley and Spash (1993) report consumers' 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 on goodness-of-fit criteria (providing the dependent variable is logged in both), but not between models with differing dependent variables. Rao and Miller (1971) define a test that allows the linear and logged dependent variable models to be compared. Willis and Garrod (1991) suggest selecting the model which best predicts visitor numbers across sites. Both of these methods are useful in selecting the TGF functional form.

Unless the zones are composed of equal populations, the variance of the observation from each will differ. Bowes and Loomis (1980) suggest using a form of weighted least squares to correct for the heteroskedasticity that so arises. While improvements to Bowes and Loomis' method of correction were suggested by Christensen and Price (1982) and Vaughan, Russell and Hazilla (1982), these papers also recognised the significance of the problem. Cooper and Loomis (1993) note that use using the log of the dependent variable minimises heteroskedasticity.

4.3 Survey design

A TCM study of duck hunting in the USE region ideally would 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 in a succession of dry years. Hence, the quality of hunting was not as good as the long-term average. The reduced quality is reflected in the number of hunters who participated in duck hunting in the USE during the year 2000 open season. 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) participated in the annual 'Wetlands and Wildlife Organised Shoot'. Hence, the most practical alternative to sampling all hunters is to survey hunters participating in the 'Wetlands and Wildlife Organised Shoot'. A survey was therefore designed for implementation at the year 2000 event.[2]

The intended survey methodology determines, in part, the design and structure of the questionnaire. In order to maximise response rates and minimise respondent cost it was decided that 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.

As the survey was being distributed as part of registration procedures minimal introduction of the questionnaire and explanation of the purpose of the survey was required in the document. Questions by

[2] There is some potential that the attraction of the opening shoot could lead to a sample biased towards hunters from further from the USE and hence a higher average consumers' surplus estimate. However, local hunters who hunted at other locations at the same time have lower costs of shooting hence the potential for a larger CS from hunting and a lower average consumers' surplus estimate.

hunters about the survey were answered by an assistant[3] who was trained about the survey's purpose and structure. The questionnaire consisted of the following sections:

- A short preamble including who is collecting the information and the use of that 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 basic questionnaire was based on Bennett's (1995) suggested simplified format. Draft versions were reviewed by Wetlands and Wildlife officers and provided for comment to local Department of Environment and Heritage officers. Minor wording changes were made to the survey after comments were received. A sample questionnaire is included in this Research Report as Appendix 3.

The questionnaire was designed to collect the following information:

1. Respondents usual place of residence (Question 1).
2. Method of transport to the event (own transport, with friends or other) (Question 2).
3. The number of people with whom they had travelled (Question 3).
4. The range of potential substitute hunting areas they had accessed in the previous twelve months (Question 4).
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).

4.4 Survey implementation

The survey was intended to estimate hunter values from participating in duck hunting in the USE region. Hence, the population to be surveyed was individuals who undertook duck hunting in this area (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 500 duck hunters during good seasons. Hence, the questionnaire was designed to be implemented at the 'Wetlands and Wildlife Organised Shoot' held on 12 February 2000, on wetlands owned by the 'Wetlands and Wildlife' trust in the USE. As indicated above, the survey was designed to be very brief and completed alongside other registration procedures.

An assistant was trained to answer questions on: the aims of the survey; the basic survey methodology; and, how the data would be used. 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.

5 Results

5.1 Response rate

A total of 294 hunters attended the year 2000 'Wetlands and Wildlife Organised Shoot'. Questionnaires were distributed to hunters during registration procedures. 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 giving a response rate of 65.6 percent across all hunters attending the shoot.

5.2 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). Prior to undertaking this analysis, the zones must be established from the data in the questionnaire. 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 composition.

[3] Mr Paul Wainwright.

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. Some groups with small numbers that are seen to be outliers (such as international visitors) sometimes must be excluded – however this was not necessary in the USE study. The final zones used for the USE duck hunting TCM are shown in Table 2. In Figure 1, the travel time is plotted against the cost of attending the hunt. As shown in Table 2, the population of the zones varies significantly. Hence, heteroskedasticity of the type suggested by Bowes and Loomis (1980) is potentially present in the model.

Table 2: USE duck hunting TCM zones

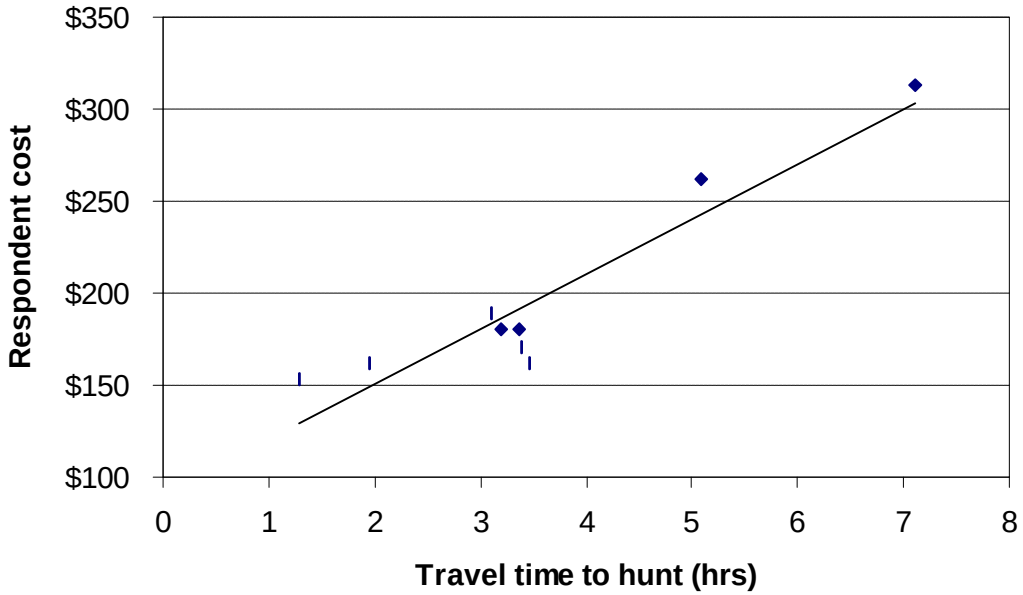
Zone	Male population over 15 years[#]	Number of hunters	Mean cost of respondents	Mean travel time*
1. Local	2845	24	$152.92	1.281
2. Naracoorte and districts (also includes Murray Bridge)	19789	39	$162.31	1.949
3. Adelaide	428248	27	$180.19	3.206
4. Lower South East remainder	12577	18	$171.11	3.389
5. Horsham and district	9893	28	$189.64	3.107
6. Central and Northern Victoria	125805	18	$261.67	5.083
7. Melbourne and surrounds	1297696	14	$312.86	7.107
8. North Wimmera	9290	11	$180.91	3.364
9. Hamilton and districts	14019	12	$162.50	3.458

* 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'.

Note: Two surveys were rejected because of incomplete data.

Figure 1: Duck hunter travel time and cost



5.3 Travel costs

The cost to hunters of attending the hunt can be measured using a variety of measures as indicated earlier. Respondents were asked to provide an estimate of their monetary costs of attending the hunt. The respondent estimate is of the marginal monetary costs of attending the hunt. The respondent estimate does not include the opportunity costs of attending the hunt. Since the length of the hunt was the same for all hunters, it was not possible to identify the value of time on site. 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 consumers' 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 the ABS (2001) divided by the mean number of hours worked by males in 1998-99. The hourly wage rate calculated using this methodology was $19.09 per hour. Hence, five alternative measures of the travel cost to participate in the hunt have been generated.

The potential for multiple purpose trips to affect cost estimates was also raised in Section 4.2. 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 3. Table 3 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. That is, the trip would not have been undertaken if there was no opportunity to participate in the shoot. Therefore, the data were not adjusted for multiple purpose trips, as it was considered unlikely that the three observations would bias the results.

Table 3: 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	13	5	1	-
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.

5.4 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 visitation rate is calculated by dividing the number of visits from each zone by the number of males over 15 living in each zone.

5.5 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. As indicated there are a number of alternative functional forms available (semi-log, double log and quadratic) and two alternative methods of estimation (ML and OLS). Furthermore, the non-constant variance of the dependent variable suggested that a weighted estimation procedures could be appropriate to estimate the relationship (WML or WLS).[4]

Three alternative functional forms were investigated:

a) Semi-log dependent: log (visit rate) = a + b travel cost
b) Semi-log independent: visit rate = a + b log (travel cost)
c) Double log: log (visit rate) = a + b log (travel cost)

Decisions between (a) and (c) can be made using model validity, R-squared and accuracy of predicted hunter numbers. Scaling the dependent variable per Rao and Miller (1971) allows likelihood ratio tests

[4] Use of a Poisson estimator for count based data was also considered for the non-linear model but none of the econometrics programs that were available could estimate Poisson regressions for the required specification.

between (b) and (a) or (c). Model validity can be used to assist in making decisions between (b) and (a) or (c). Christensen and Price (1982) note that predicted hunter numbers at no change to the entry fee is not a suitable criterion if it leads to an incorrect model specification and incorrect consumers' surplus estimates. Hence model validity is the primary selection criteria and predicted hunter numbers the secondary criteria.

Preliminary 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 poorly predicted (over 100 hunters versus just 27 in reality). This was possibly due to differences in population preferences between capital cities and rural areas. Because of the large differences, Adelaide is also acting as an outlier on remaining predictions. A dummy variable for capital cities (Adelaide and Melbourne) was therefore included in the model to eliminate the capital city effect.

The dependent variable semi-log model was not significantly different from the double log model (models (a) and (c)). Model (a) was selected due to simplicity of estimating results and model validity over model (b).[5] The Rao and Miller (1971) scaled likelihood ratio test indicated no significant difference between models (a) and (c) but both model (a) and (c) were significantly different from (b) at the 1 percent level. The preliminary model estimated was:

Log (visit rate) = a + b.travel cost + c.Capcity dummy

With no time costs included, the OLS estimated TGF is:

Log (visit rate) = -2.604 – 2.10E-2.travel cost – 2.785.Capcity dummy
(1.243) (0.007) (0.801)
Note: numbers in brackets are standard errors
Model R^2adjusted = 0.847, F probability = 0.002

Cooper and Loomis (1993) indicate that potential heteroscedasticity due to zones with differing population sizes is likely to be minimised by the logged dependent variable.[6] A simple test for heteroscedasticity involving the plotting of prediction error against population for the logged dependent variable indicated that there was little likelihood of its presence in the model. This finding was confirmed by a Breusch-Pagan test.

In Table 4 the five models estimated in order to test the sensitivity of the results to the inclusion of a cost for travel time are reported.

Table 4: OLS models for travel time cost sensitivity

Coefficients	Travel time cost				
	Base	0.25 cost	0.5 cost	0.75 cost	Full cost
a	-2.604	-2.737	-2.859	-2.968	-3.065
	(1.243)	(1.154)	(1.088)	(1.037)	(0.997)
b	-2.10E-2	-1.87E-2	-1.69E-2	-1.53E-2	-1.40E-2
	(0.007)	(0.006)	(0.005)	(0.004)	(0.004)
c	-2.785	-2.744	-2.717	-2.698	-2.685
	(0.801)	(0.783)	(0.770)	(0.762)	(0.755)
R^2-adjusted	0.847	0.855	0.861	0.864	0.867
F (Sig.)	0.002	0.001	0.001	0.001	0.001

Note: Bracketed numbers are standard errors

[5] The double log model estimation is used to demonstrate the two-stage estimation methodology in Appendix 2. These estimates also show the difference in consumers' surplus estimates from models that are not significantly different from each other.

[6] Furthermore, using WLS or GLS (as per Bowes and Loomis (1980)) would expose the methodology to the criticisms made by Christensen and Price (1982). That is, the greatest weighting is given to zones further from the hunting site by virtue of their larger populations. Hence, the weighting procedure suggested by Christensen and Price (1982) was not suitable for the data even if heteroscedasticity were present.

The TGF can also be estimated using non-linear least squares (NLSQ) (NLSQ is a ML based methodology). ML based estimation eliminates some concerns previously indicated regarding the OLS estimation of the TGF relationship. The results, which are reported in Table 5, are very similar to the OLS methodology used above. Consumers' surplus estimates will also be calculated from these estimates.

Table 5: Non-linear least squares models for travel time cost sensitivity

Coefficients	Travel time cost				
	Base	0.25 cost	0.5 cost	0.75 cost	Full cost
a	-2.455	-2.532	-2.657	-2.794	-2.925
	(0.995)	(0.923)	(0.858)	(0.804)	(0.760)
b	-2.36E-2	-2.15E-2	-1.95E-2	-1.77E-2	-1.61E-2
	(0.005)	(0.005)	(0.004)	(0.004)	(0.003)
c	-2.990	-2.897	-2.876	-2.854	-2.832
	(0.437)	(0.421)	(0.412)	(0.407)	(0.404)
R^2-adjusted	-0.452	-0.348	-0.289	-0.249	-0.228

Note: Bracketed numbers are asymptotic standard errors, R^2-adjusted is not bound in [0,1].

5.6 Other modelling issues

The potential impact of substitutes was mentioned Section 4.2. As indicated the questionnaire included a question relating to visits to other duck hunting areas during the previous twelve months. Respondents were asked to indicate where and how many times they had been hunting in five pre-specified areas and to nominate any other areas they had been duck hunting. The frequency of visitation information indicates the number of times each areas was hunted in by various groups compared to the USE but was not sufficiently detailed to allow inclusion of a substitute price coefficient. The areas in which respondents hunted are shown in Table 6.

Table 6: Number of trips per hunter to substitute duck hunting areas by zone

Zone	**Number of trips per hunter to area in last twelve months**						
	USE	LSE	Lower SA Murray[#]	Upper SA Murray[#]	Victoria	Other	Total trips
1.	2.92	0.04	0.17	0.00	0.04	0.04	*3.21*
2.	0.38	0.56	0.03	0.05	0.31	0.38	*1.72*
3.	1.22	0.07	1.19	0.07	0.11	0.44	*3.11*
4.	0.95	0.84	0.21	0.21	2.79	0.21	*5.21*
5.	0.46	1.11	0.18	0.04	9.54	1.04	*12.36*
6.	0.78	0.28	0.00	0.00	13.44	6.94	*21.44*
7.	0.71	0.07	0.00	0.00	3.43	0.29	*4.50*
8.	2.18	0.64	0.00	0.00	17.45	1.91	*22.18*
9.	2.00	0.08	0.00	0.00	7.08	0.31	*9.46*

[#] Lower SA Murray is the Murray River and floodplain below Murray Bridge including lakes Alexandrina and Albert. The Upper SA Murray is the Murray River and floodplain above Murray Bridge.

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 7. 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 one or more the 1999 'Wetlands and Wildlife Organised Shoots'. Table 7 shows there were very few substitutes within South Australia during the last twelve months. Only South Australian hunters within the Lower South East (LSE) area had a substitute within the LSE.

Victorian hunters had a larger number of substitute regions. All hunters in Central and Western Victoria have at least two substitute regions. The substitute variable shown in Table 7 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 7 were not available at the time of the shoot confounding their impact on the model.

Table 7: 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. The Upper SA Murray is the Murray River and floodplain above Murray Bridge.

Note: Substitutes are defined as more than one third of hunters from the zone have hunted in that area in the previous twelve months.

A second potential influence on travel costs and hence the visit rate is whether hunters travelled to the shoot alone or with friends. Hunters travelling as a group presumably lower their costs of attendance. The proportion of hunters in each zone who travelled with friends is shown in Table 8. The proportions were also included as an explanatory variable, however the coefficient was insignificant. It is likely that the impacts of the variable were incorporated in the self-estimated travel costs as respondents were asked to indicate the costs of their trip (rather than group costs).

Table 8: Proportion of hunters travelling to shoot with friends

Zone	Proportion travelling with friends
1. Local	0.208
2. Naracoorte and districts (also includes Murray Bridge)	0.308
3. Adelaide	0.259
4. Lower South East remainder	0.316
5. Horsham and district	0.393
6. Central and Northern Victoria	0.444
7. Melbourne and surrounds	0.357
8. North Wimmera	0.455
9. Hamilton and districts	0.538

5.7 Consumers' surplus estimation

Estimation of consumers' surplus is undertaken via a two-stage approach in most TCM applications. The first stage utilises the TGF to simulate demand for hunting under different pricing conditions. That is, to derive a demand curve for duck hunting. The second stage is to estimate the area under the demand curve at the current level of hunting fees. For completeness, the two-stage approach is demonstrated for the same model in Appendix 1.

For some functional forms, the consumers' surplus can be estimated directly from the TGF (see for example, Hanley and Spash (1993), Offenbach and Goodwin (1994)). In the case of the log-linear form applied in this study the average per-capita consumers' surplus is[7]:

CS = -1 / (travel cost coefficient)

Hence, for the base (OLS) relationship:

CS = -1/ 0.210E-2
= $47.73 per visit

A 95 percent confidence interval is calculated as follows:

-1 / (0.210E-2 – 1.96SE) < CS/visit < -1 / (0.210E-2 + 1.96SE)

where: SE = standard error of travel cost coefficient

Hence the 95 percent confidence interval is:

$29.58 < CS/visit < $123.50

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 (294). Hence, the base level total consumers' surplus for the 2000 Shoot is $14,033. The equivalent estimate for the ML estimates is slightly lower at $12,439 or $42.31 per visit. Similarly, the consumers' surplus can be extrapolated across 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 9. There is a large difference between estimates. The full cost estimate is 50 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. The consumers' surplus estimates from the NLSQ estimation are also included in Table 9. NLSQ estimates are around 12% percent lower than the OLS estimates and have much tighter confidence intervals.

Table 9: Sensitivity of estimates to inclusion of cost of travel time

Estimate	OLS			NLSQ		
	Base	0.5 cost	Full cost	Base	0.5 cost	Full cost
Individual CS	$ 47.73	$ 59.20	$ 71.39	$ 42.31	$ 51.33	$ 62.03
95% upper	$123.50	$138.17	$159.46	$ 76.14	$ 87.04	$101.81
95% lower	$ 29.58	$ 37.67	$ 45.99	$ 29.30	$ 36.40	$ 44.61
Total CS	$14,033	$17,406	$20,987	$12,439	$15,092	$18,238

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 Net Present Value (NPV) the consumers' surplus is expressed as an annuity that would be received for 30 years. The present value of the annuity is multiplied by the inverse of the selected discount rate to estimate the NPV. Estimates of the NPV are shown in Table 10.

Two issues need to be clarified prior to estimating an NPV. Firstly, the year 2000 duck-hunting season's quality was worse than historical averages. While this did not affect the number of hunters at the opening shoot to a large degree (294 versus an average of 340) the overall impact on 2000 was just 555 hunters versus over 1300 in all years. Hence, the appropriate NPV for duck hunting on Wetlands and Wildlife properties alone will be higher than that estimated using year 2000 numbers. Wetlands

[7] The mathematical derivation of this relationship is provided in Appendix 2.

and Wildlife provided data on the number of shooters attending the opening shoot and later shoots 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 10.

Secondly, as indicated in Table 6, some hunters make more than one hunting trip to the USE and these trips may be undertaken to alternative sites within 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 are dominated by respondents living closer to the wetlands. Wetlands and Wildlife data verify this assessment indicating that over three-quarters of all hunting trips to their wetlands occur in later hunts during the season. The long-term average of hunter numbers is the base aggregate consumers' surplus. The upper and lower points of the 95 percent confidence interval are used to test the sensitivity of these assumptions. Hunting on non-Wetlands and Wildlife wetlands in the Upper South East is not included in Table 10 as no numbers are available to estimate these trips. Thirty-nine percent of landholders report undertaking hunting in their wetlands (about 30 landholders). Hence, it is likely that well over 350 additional hunting trips are undertaken in the USE when it is considered that friends and family often join in such events. The third column of Table 10 is an estimate of total consumers' surplus for the Upper South East. No fee is charged for such hunts and travel costs are often lower because friends and neighbours generally live close by. This would leave a higher consumer surplus for hunters to enjoy. However, the same factors suggest that more trips may be made which could lead to a lower average consumer surplus. Therefore, the same consumers surplus is conservatively applied to these hunting trips. Sensitivity tests of the USE total are shown in the final two columns.

Table 10: Estimates of NPV for hunting ducks in the USE from NLSQ model

Model used	1st shoot 2000	W&W mean annual total	Total USE estimate	Upper USE sensitivity	Lower USE sensitivity
Base model	$154,362	$606,945	$787,559	$525,039	$1,050,079
50% cost travel time	$187,283	$736,392	$955,527	$637,018	$1,274,035
Full cost travel time	$226,317	$889,874	$1,154,680	$769,787	$1,539,574
Number of hunters	294	1156	1500	1000	2000

Note: NPVs calculated over 30 years using a 7 percent discount rate.

The extrapolation of the survey data assumes similar travel costs and quality of the hunting experience. 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 for hunting. Each of these wetlands may also be some distance from the centralised meeting point.

5.8 Estimation of producers surplus

All hunters participating in Wetlands and Wildlife organised shoots must pay a hunting fee of $20. Most of the inputs to the hunt (such as labour, access construction and management and other inputs) are donated to 'Wetlands and Wildlife'. Hence, the hunting fee is a proxy for the producers' surplus, or profit, that the hunt generates to the wetland owner. The NPV of the future stream of producers' surplus can be estimated in a similar way to the consumers' surplus and is reported in Table 11. The NPV of the producers' surplus, assuming duck hunting continues on Wetlands and Wildlife properties at current average levels is $286,897. As for the consumers' surplus estimates, sensitivity tests can be conducted. In the final two columns of Table 11, sensitivity tests are reported for the 95% confidence interval of the mean number of hunters over the last 13 years.

Table 11: Estimates of Producers' surplus NPV for hunting ducks in the USE

Model used	1st shoot 2000	W&W mean annual total	Upper W&W sensitivity	Lower W&W sensitivity
Base model	$72,965	$286,897	$385,921	$187,625
Number of hunters	294	1156	1555	756

Note: NPVs calculated over 30 years using a 7 percent discount rate.

6 Conclusions

The aim in this Research Report 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' and the revenue generated for Wetlands and Wildlife by the 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 consumers' surplus of between $42.31 and $62.03 (based on ML estimates). 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 consumers' surplus of between $12,439 and $18,238 for the year 2000 event. Extrapolating these estimates across all years generates a NPV estimate of between $606,945 and $889,874 for the entire seasons hunting on Wetlands and Wildlife wetlands. Wetlands and Wildlife generate a further producers' surplus of $286,897 from fees to participate in the organised shoot. Further extrapolation across duck hunting in all USE wetlands produces a NPV estimate of between three quarters of a million and over a million dollars. Hence, the total surpluses generated by hunting in USE wetlands are likely to exceed one million dollars.

The estimates that are reported in this Research Report comprise 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 cost-benefit framework. This framework will be used to assess the likely net benefits (or costs) of undertaking management changes in USE wetlands. The outcomes of the USE cost benefit analysis will be reported in Research Report 9. 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 Research Report 8.

However, a benefit-cost analysis of duck hunting in the USE 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. Indeed many wetland owners hunt ducks in their own wetland areas. The same hunting actions generate a cost to the wider community via their distress over the killing of waterfowl. Secondly, wetland owners trade-off the costs of 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 the resulting potential biophysical costs (or benefits) to species in wetlands is the unknown link.

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Appendix 1: Two-stage estimation of consumers' surplus

A1.1 The demand function

The alternative method of estimating the consumers' surplus is demonstrated in this Appendix. Using this method, 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.

As indicated in Section 5.5 this appendix is also being used to demonstrate consumers' surplus derived from the log-log model. The base log-log model is as follows:

Log (visit rate) = a + b.log (travel cost) + c.Capcity dummy

With no time costs included, the OLS estimated TGF is:

Log (visit rate) = 18.178 – 4.739.log (travel cost) – 2.812.Capcity dummy
(7.270) (1.398) (0.763)
Note: numbers in brackets are standard errors
Model R^2adjusted = 0.858, F probability = 0.001

The simulation exercise is undertaken by predicting the number of hunters from each zone, at the original estimated cost of that zone. The cost is then raised by $5 and the process repeated. This step is repeated for cost increases of up to $125. Increases in current costs are a simulated entry fee increase (or participation fee increase). 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 a price level is the level of demand for hunting at that price level. 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 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 proved to possess the best model validity on the basis of R-squared adjusted for the number of coefficients. The model used was:

Log (hunting fee increase) = a + b.hunters

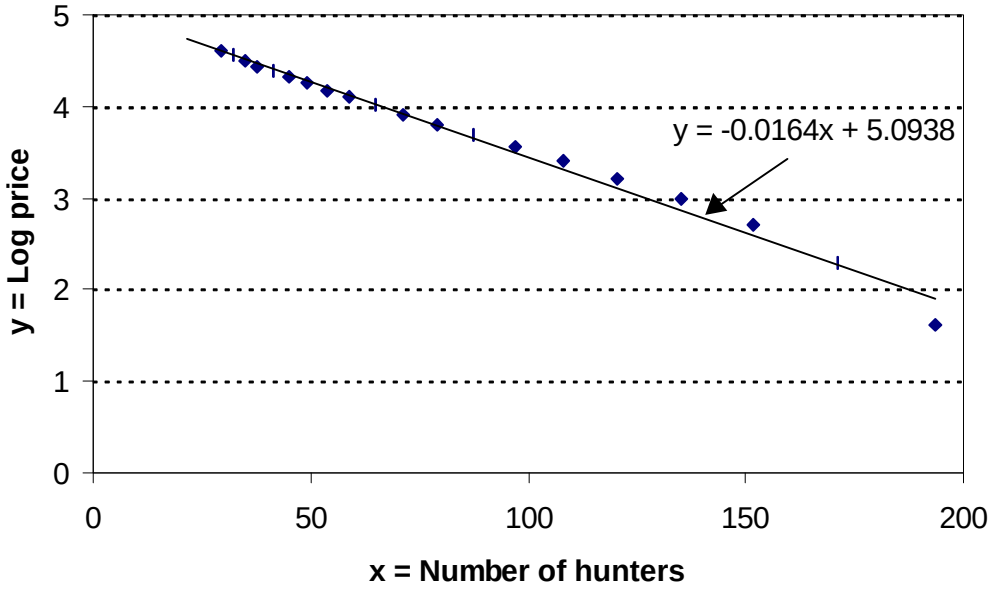
The base model demand curve is plotted in Figure A1 and specified in Table A1.

Table A1: Demand curve equations for duck hunting in the USE

Coefficients	Base model (OLS)
a	5.107
	(3.07E-2)
b	-1.66E-2
	(3.49E-4)
R^2	0.990
F (Prob)	0.000

Note: Bracketed numbers are standard errors

Figure A1: Demand for duck hunting in the USE of SA



A1.2 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.[8]

In the case of a double-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 A2), plus the area between the upper price and minimum number of hunters (area B in Figure A2). Because a double-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 predicted number of hunters. The lower point is arbitrarily set at the level of visits that corresponds with a $120 increase in the current level of fees. At this level, most of the responsiveness to the simulated changes in the participation fee has been exhausted. The areas calculated for the consumers' surplus calculation are shown in Figure A2. The point of truncation can be a big influence on the magnitude of the consumer surplus that is estimated as the tail above the truncation is ignored.

The integration process is set out below:

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

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

Hence, $$\text{Area } A = e^{a} / (b+1) * [H^{b+1}]_{\text{fee increase = \$0}}^{\text{fee increase = \$120}}$$

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:

[8] 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.

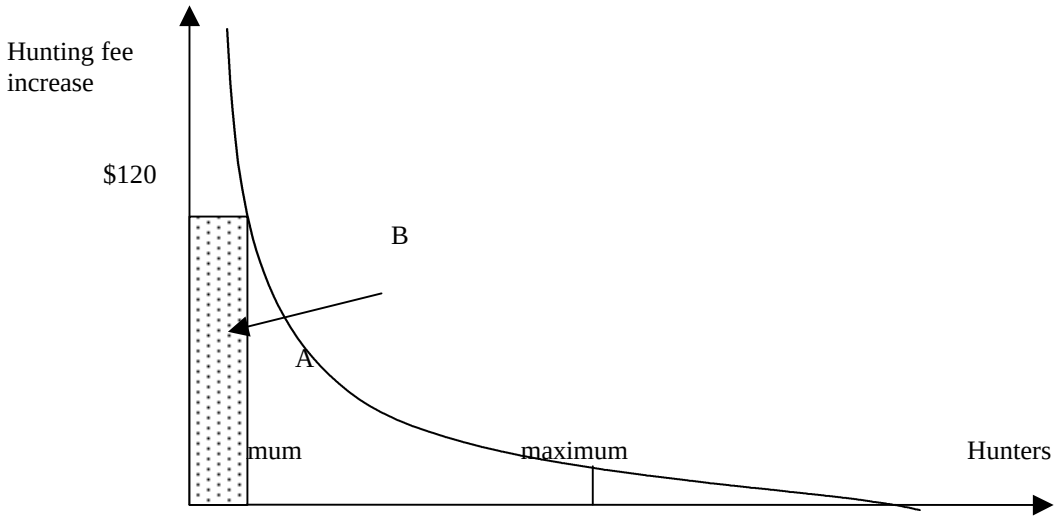
$$CS = A + B = e^{5.107} / 0.983 * [e^{0.983 * 220} - e^{0.983 * 20}] + 20 * 120$$

$$= 167.896 * 182.175 + 2400$$

$$= \$32986.43$$

The consumers' surplus calculated represents that of the 220 hunters predicted by the model. The per-visit consumers' surplus is $149.94. This is the total consumers' surplus divided by the predicted number of hunters.

Figure A2: Calculation of consumers' surplus



This appendix has two aims:

1. To demonstrate the alternative two stage methodology to estimate the consumer surplus when a mathematical one stage derivation is not possible; and,
2. To estimate the consumer surplus that would result from a log-log model specification.

The finding that the consumer surplus estimate is significantly larger than that resulting from the log-linear model emphasises the importance of the choice of functional form. There is no significant difference between the two models on theoretical grounds or on statistical performance criteria. The relatively small sample size (193) and resulting small number of zones (nine) means that the statistical power of the models is reduced, and may contribute to the large difference between the consumers' surplus estimates. Hence, the decision to use the log-linear model specification in the text of this Research Report is based on the use of a conservative estimate of the consumers' surplus generated by duck hunting in the USE region.

Appendix 2: Mathematical derivation of consumers' surplus from trip generator function

The log linear function estimated is:

$$\text{Ln}(VR_i) = a + b.TC_i + c.\text{Cap city dummy}$$

$$VR_i = e^{(a + b.TC_i + c.\text{Cap city dummy})}$$

Where: VR_i = hunters from zone i/ male population of zone i
TC_i = travel cost for zone i
Cap city dummy = dummy variable for zone including a state capital

Average consumers' surplus is:

$$CS/\text{visit} = -1 / b$$

Proof[9]

$$CS_i / Person = \int_{TC_i}^{\infty} VR_i \, dTC = \int_{TC_i}^{\infty} ae^{bTC_i} \, dTC = \frac{a}{-b} e^{bTC_i}$$

$$CS / visit = \frac{CS_i / person}{visits_i / person} = \frac{\frac{a}{-b} e^{bTC_i}}{ae^{bTC_i}} = \frac{1}{-b}$$

Hence, consumers' surplus is not dependent on the zone from which the visit is made.

[9] The proof is drawn from notes provided by Dr Geoff Kerr.

Appendix 3: Survey of Hunters

Wetlands and Wildlife Organised Shoot 2000

The following information is being collected by The University of New South Wales in conjunction with Wetlands and Wildlife for use in research relating to hunting in the Upper South East region.

To be completed by all hunters

All your answers will be kept strictly confidential

Question 1

In which city or town is your usual place of residence? (If you live out of town, please indicate your nearest city or town.)

City/town_____ State _____ Postcode _____

Question 2

How did you travel to the open shoot? *Please tick (✓) one box.*

Own transport ☝1

Travelled with friends ☝2

Other (please specify):_____ ☝3

Question 3

How many people are in your group? _____ people

Question 4

How many times have you been duck hunting in the following areas in the last 12 months?
Please indicate the number of times for each area in the appropriate box.

The Upper South East region (excluding Bool Lagoon, Hacks Lagoon and other Lower South East areas)? ☝1

The Lower South East (including Bool and Hacks lagoon)? ☝2

The Murray and floodplain below Murray Bridge (including Lake Alexandrina and Albert)? ☝3

The Murray and floodplain Murray Bridge to the SA border? ☝4

Victoria? ☝5

Elsewhere? Please list:_____ ☝6

Question 5

Please estimate the total cost of your trip (including hunting fee) $_____

Question 6

How long did it take you to travel to the shoot? _____ hours

Question 7

Is participation in the Wetlands and Wildlife Organised Shoot the sole purpose of your trip?

Please tick (✓) one box.

Yes G1 **No** G2

If you answered YES to Question 7 you have completed this questionnaire. Otherwise please answer Question 8.

Question 8

How important is your group's participation in the Wetlands and Wildlife Organised Shoot, relative to the other things your group is doing on this trip?

Please tick (✓) one box only.

Very important G1

Moderately important G2

Slightly important G3

Not at all important G4

We would like to thank you for your cooperation in completing this questionnaire.

If you would like any further information about this survey please contact Stuart Whitten on 02 6268 8073.

Please use the space below to make any comments.

Previous Research Reports in the Series

Whitten, S.M. & Bennett, J.W. (1998). *Wetland Eco Systems and Landuse in the Upper South East of South Australia,* Private and Social Values of Wetlands Research Report No. 1, University College, The University of New South Wales, Canberra.

Whitten, S.M. & Bennett, J.W. (1998), *Farmer Perceptions of Wetlands and Wetland Management in the Upper South East of South Australia*, Private and Social Values of Wetlands Research Report No. 2, University College, The University of New South Wales, Canberra.

Whitten, S.M. & Bennett, J.W. (1999). *Potential Upper South East Regional Wetland Management Strategies*, Private and Social Values of Wetlands Research Report No. 3, University College, The University of New South Wales, Canberra.

Whitten, S.M. & Bennett, J.W. (1999). *Wetland Eco Systems and Landuse in the Murrumbidgee catchment – Wagga Wagga to Hay and including Mirrool Creek*, Private and Social Values of Wetlands Research Report No. 4, University College, The University of New South Wales, Canberra.

Whitten, S.M. & Bennett, J.W. (2000). *Farmer Perceptions of Wetlands and Wetland Management on the Murrumbidgee River between Wagga Wagga and Hay including Mirrool Creek*, Private and Social Values of Wetlands Research Report No. 5, University College, The University of New South Wales, Canberra.

Whitten, S.M. & Bennett, J.W. (2000). *Potential Wetland Management Strategies – Murrumbidgee Floodplain Wagga Wagga to Hay*, Private and Social Values of Wetlands Research Report No. 6, University College, The University of New South Wales, Canberra.

Whitten, S.M. & Bennett, J.W. (2001). *Non-market value of wetlands: A choice modelling study of wetlands in the Upper South East of South Australia and the Murrumbidgee River floodplain in New South Wales*, Private and Social Values of Wetlands Research Report No. 8, University College, The University of New South Wales, Canberra.