AN ABSTRACT OF THE THESIS OF

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Title: ESTIMATION OF NET ECONOMIC BENEFITS OF THE OREGON BIG GAME RESOURCE TO HUNTERS

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Much outdoor recreation occurs on publicly owned land and water resources, or involves use of these public resources. Consequently, an economic problem arises concerning the value of recreational resources which do not have a conventional market price. Without a price to guide the allocation of resources, it is difficult to obtain optimal decisions in allocation of these publicly owned natural resources among alternative uses, including recreation, timber, and domestic livestock production.

In Oregon, the big game resource has a great impact on the economy of the state. Positive values of this resource are related to recreational use and to income generated which benefit local economies. Negative values of big game include its competition for resources used for timber production and/or livestock grazing.

In order to better assess the value of the big game resource, an attempt has been made in this thesis to improve demand models from which

the net economic value of the Oregon big game resource can be derived. The data used in this study were obtained from the questionnaires mailed to a random sample of Oregon big game hunters during the fall of 1968.

The travel cost method was used to estimate the demand for big game hunting, based on the actual behavior of the hunters. Several algebraic forms of the travel cost demand equation were estimated for the Northeast and the Central regions of Oregon.

The concept of consumers' surplus was used to estimate the net economic value for the Oregon big game resources. Net economic value for the Northeast and Central regions of Oregon in 1968 dollars was approximately $14.3 million, based on the exponential demand function. Net economic value for the same two regions was approximately $11 million, based on the linear demand function.

An attempt was made in this study to predict the changes in consumers' surplus from changes in the number of deer and elk harvested. Note that the regression models in this thesis implied that a ten percent increase in harvest would increase the consumers' surplus of hunters by more than ten percent. However, the hypothesis that a ten percent increase in harvest would increase consumers' surplus by exactly ten percent was not rejected by a statistical test. Therefore, a good deal more research is needed to determine the value of marginal changes in the number of deer and elk harvested.

It is thought that the estimation of net economic value in this study for the Northeast and Central regions of Oregon will be useful from the viewpoint of big game management and resource allocation in Oregon.

Estimation of Net Economic Benefits of the
Oregon Big Game Resource to Hunters

by

Faisal M. Shalloof

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I. INTRODUCTION AND PROBLEM STATEMENT

Justification

Various socio-economic and technological changes in American life, such as increase in leisure time, income, population, and mobility, have contributed to an upsurge in outdoor recreational activity. Much of this outdoor recreation involves use of a public resource. Consequently, an economic problem involves quantifying the value of recreational resources which do not have a conventional market price.

Without a price to guide or direct the allocation of resources, it is difficult to obtain optimal decisions in allocation of these publicly owned natural resources among many competing alternative uses. With regard to the big game resource, conflicting uses include recreation, timber, and domestic livestock production. An additional consideration includes the long term well-being of the natural environment, which has implications for the management of water and water-related land resources.

In Oregon the big game resource is an important component of the total natural resources of the state. Big game is an important source of income to certain sectors of the economy because of the money spent by hunters on investment items and trip expense (Nawas, 1973). Improved knowledge regarding the economic value of the Oregon big game resource would be useful to many Oregon industries, local economies, and natural resource management agencies.

Hunters would be expected to favor management practices that would lead to greater deer and elk numbers because the probability of killing an elk or a deer will increase with the increase in herd size, at least for herds east of the Cascade Mountains. Due largely to the competition among uses and users for limited land and water resource, the number of deer and elk has become a controversial issue in Eastern Oregon, resulting in heated disputes among ranchers, foresters, and hunters concerning elk and deer management. It is disconcerting, to say the least, to ranchers to be feeding expensive hay to domestic livestock and simultaneously seeing the deer and elk eating their limited early spring pasture before sufficient growth has been established, as well as depleting the late fall and early winter grazing (Sandrey, 1980). Similarily for timber production, elk damage to young trees presents a problem for foresters (Francy, 1980). With the increase of elk numbers, this problem is magnified in some areas. Soil erosion may become a serious problem with overgrazing of early spring pasture. Trampling caused by large herds of elk and deer may also lead to long-term deterioration of the ecosystem during poor growing seasons.

Valuation Problems and Procedures

Wildlife biologists have long known the importance of estimating values of wildlife. At the same time they have recognized that the wildlife resource must be managed with several types of value kept simultaneously in mind. King (1947) listed six such values: commercial, recreational, biological, social, aesthetic, and scientific. He said that, "the total economic value of the wild resource is: (the sum of all its positive values), minus the sum of all its negative values plus the cost of control and harvest)."

Economic studies of wildlife have been made in several states, and often these studies have dealt with big game, for example, Pasto and Thomas (1955) in Pennsylvania, and Davis (1962) in Arizona. Here, as in other states and national research, emphasis was on dollars and cents expended in relation to wildlife. An example of the resource economics approach to the problem is seen in publications by Brown, Singh, and Castle (1964) and Brown, Nawas, and Stevens (1973).

Increased emphasis on recreation in America has resulted in more interest in recreational values and in efforts at standardization of terminology and methods of measuring demand and value of outdoor recreation (Clawson, 1959; Casario and Knetsch, 1976; Dwyer, Kelly, and Bowes, 1977; Brown, Sorhus, and Gibbs (1980). Development of similar standards would seem a first step in the further study of wildlife values.

Problem Statement

The Oregon big game resource has a substantial impact on the economy of the state. Positive values of this resource are related to recreational use, income generated to benefit local economies, and as a protein source. Negative values include their role of damage to forage and to other property of value to man.

Resolution of the problem arising from the simultaneous use of land for several purposes would reduce social conflict in society. It would also decrease economic losses and enhance the gains possible under wise use of land. The development of improved numerical estimates of the net economic value of the Oregon big game resources to hunters and society is needed to help resolve these conflicts. Net economic value is approached by treating the hunting activity as if hunters could be charged for it so as to approximate their so-called "willingness to pay." This hunting charge can be described as the sum of two components: the actual market expenditure by hunters plus any excess amount which hunters might be induced to pay. An approximation of willingness to pay for particular recreation opportunities can be developed from a demand curve which indicates the quantity of use that participants in a market would be willing and able to purchase at each price.

There are some data available from an earlier study which can be used to provide an improved estimate of economic benefits to hunters from the Oregon big game resource. The data were based upon two questionnaires mailed to hunters in 1968.

Note that even improved estimates of net economic benefits to hunters would not, in themselves, provide sufficient information to resolve the problems of conflict in resource use by the different groups mentioned earlier. However, estimates of the net economic benefits from some of the other uses of the resource are already available or can be computed. For example, cattle prices and ranching costs are known or can be estimated, and the same is true for timber production, harvesting, and marketing.

At this point it should also be noted that this thesis, even with good estimates of the values or prices of all products, will not solve some of the problems associated with the big game resource. For example, the willingness to pay by the hunters is not directly related to the economic activity generated by hunting. It is true that the economic impacts could conceivably be estimated from some of the same data used to estimate willingness to pay. However, the 1968 data used for this thesis do not give any information about where expenditures were made. Consequently, a new survey of hunters is needed to indicate expenditure by counties. Such data could then be used to show where the economic activity generated from hunting occurs. At this time it is thought that only a small part of the total expenditures by hunters is made in the Northeast Oregon counties where most of the big game is located and hunted. However, a new survey of hunters is far beyond the scope and intent of this thesis due to time and money constraints.

The goal of this thesis is to provide managers with some of the information needed to help establish economically optimum cattle grazing levels, deer and elk herd numbers, and timber production on critical public grazing zones. To achieve that goal, the following objectives are needed:

1. To quantify the variables affecting the patterns of big game hunting.
2. To estimate by new methods the statistical demand for the Oregon big game resource, using survey data from the 1968 study, and to compare and evaluate the newer estimating methods with those obtained by traditional procedures.

The basic procedure to be used to accomplish the above objectives is the travel-cost method because it has withstood the test of time and it is generally recommended for use whenever possible to measure willingness to pay from the actual behavior of participants (Dwyer, Kelly, and Bowes, 1977, pp. 138-140).

II. REVIEW OF METHODS FOR ESTIMATING OUTDOOR RECREATIONAL BENEFITS

Dramatic growth in outdoor recreation demand has taken place during the past 30 years, stemming from increases in population, leisure time, income, and mobility. The fact that much outdoor recreation depends upon land and water creates an economic problem, specifically that of measuring the value of a recreational resource which does not have a conventional market price. Due to the absence of a market for outdoor recreation, a number of economists have responded to this challenge by developing methods to quantify the economic benefits accruing to outdoor recreation. These methods, which have proceeded in two directions, are concerned with the estimation of the money that recreationists would be willing to pay for the use of a recreational facility. Review of these two main methods, called "direct" and "indirect" respectively, is the topic of this chapter.

The Direct Method for Estimating Outdoor Recreation Benefits

The two key assumptions in the direct method used to ascertain value are: 1) that the consumer can assign an accurate value to the resource use, or in this case, the recreational experience, and 2) that this valuation can be elicited from the respondent by means of a properly constructed questionnaire. Because the situation is hypothetical in nature, the direct method is therefore subject to large errors in measurement (Bishop and Heberlien, 1979). One of the most difficult tasks of the surveyor is assigning a dollar value to recreational experience by the respondent. Understanding the question, interviewer bias, and gaming strategy are some other problems. Because of the sophisticated questioning and bidding techniques that have recently been developed there is a renewed interest in the direct method (Dwyer, Kelly, and Bowers, 1977). A good discussion of the direct questionnaire technique and its limitations is given by Dwyer et al. (1977).

The second main development of techniques for estimating recreational benefits is based upon "indirect" evidence. This evidence usually pertains to the travel and related costs incurred by the recreationist.

The Indirect Method for Estimating Outdoor Recreation Benefits

With the indirect method the willingness of the respondent to pay is measured first by estimating the respondent's demand for the resource. Because the indirect method does not rely upon the recreationalist assigning a value to the recreational experience, some have suggested that this method is the most appropriate for measuring recreational value.

The travel-cost method has been dominant over the years, and was first suggested by Harold Hotelling (1949). He suggested to the park service the drawing of concentric circles (zones) around the recreational site. The number of trips would be the dependent variable, and the increasing travel cost incurred by the recreationalists from the more distant zones could be used as a proxy for the price. It was reasoned that the increased travel costs incurred by the participants would be similar to an increase in the entrance fee at the site. It was expected that there would be an inverse relationship between increasing travel costs and the number of trips taken by recreationists, thus, specifying a demand relationship for the site. The net economic value, or willingness to pay could then be calculated by taking the definite integral of the area under the curve and above the cost of participation.

Marion Clawson's study Methods for Measuring the Demand for and Value of Outdoor Recreation (1959) was the first to empirically estimate benefits using a travel-cost framework. Clawson's study has been recognized for many years as the pioneering study in the estimation of outdoor recreational benefits. The simple travel-cost model used by Clawson has since been improved extensively, mostly as a result of the limitations of the original simple travel-cost procedure. The simple travel-cost is limited by four basic assumptions:

1. Every distance zone must have homogeneous preference functions for the recreational activity.
2. The marginal preference for travel in all zones equals zero.
3. Time and other non-monetary constraints are not a factor.
4. The price and availability of substitutes are equal for all zones.

The first limitation, homogeneous preference functions for the recreational activity for all zones, for example, assumes that individuals from far zones have the same preference for big game hunting as do individuals who live in Northeast Oregon. That is, this assumption maintains that recreationists in Multnomah County would have the same preference structure for hunting as would persons living in the Northeast, such as Wallawa County. In actual fact, it is unlikely that the people in all zones would have the same preference structure for hunting. It is possible that some persons choose to spend their entire lives in Northeast Oregon communities to take advantage of the hunting. It is unlikely that hunting would be the only reason for making the move, but if it were, it is important to know what effect it would have on the estimates of value for the Oregon big game. To find the direction of the bias, it is important to consider how the demand function would be constructed. The scatter of points in Figure 1 below represent observations from zones for the travel cost model. Zones close to the site have low travel costs and high participation rates, while zones further away have higher travel costs and lower participation rates as shown in Figure 1. D_1 represents the estimated demand curve for hunters near the site. (A linear model is used for illustrative purposes.) D_2 repesents the estimated demand for hunters further away from the site. In order to determine the direction of the bias, note that D_3 would be estimated from all the observations when assuming a homogeneous preference function

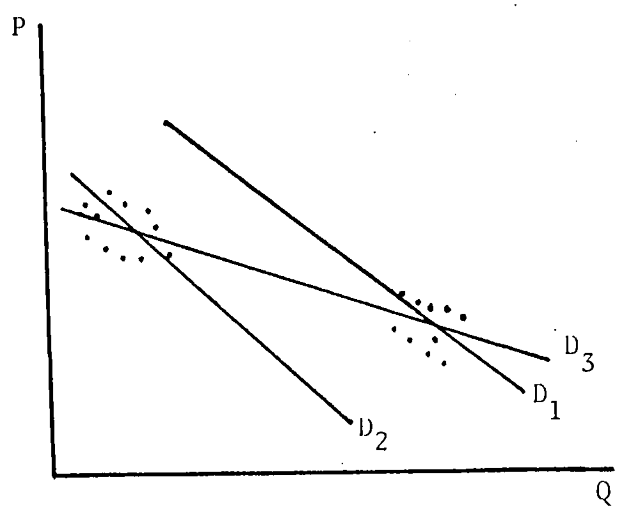

Figure 1.

for all zones. Note that the travel-cost estimate, D_3, is more elastic than either D_1 or D_2. The calculated consumers' surplus using D_3 is less than the sum of the consumers' surplus computed from the other two demand curves. Thus, the assumption of a homogeneous preference function for hunting will tend to underestimate the consumers' surplus. Therefore, although this limitation is not eliminated, the effect of the bias will result in a conservative estimate of the consumers' surplus.

The travel-cost method ignores non-monetary costs, such as travel time, and therefore is restricted by the assumption that respondents will react only to out-of-pocket expenses, such as travel costs. Knetsch (1963) pointed out that participants from further distance zones incur not only increased travel costs, but increased travel time as well. Knetsch demonstrates that if the travel time is ignored, the value of the site will usually be underestimated. There has been some attempt to measure time simply by including it as a variable in the travel cost equation, or by specifying time in terms of dollars by multiplying the round trip travel time by a percentage of the wage rate. A problem arises from the selection of an appropriate percentage of the wage rate. Dwyer, Kelly, and Bowes (1977) suggest one-half to one-third the wage rate; however, these percentages are still arbitrary.

Simply including time as a variable in the regression has been unsuccessful because of the high degree of correlation between travel cost and travel time for aggregated data. Both travel cost and travel time are functions of distance, resulting in nearly perfect multicollinearity. Cesario and Knetsch (1970) suggested combining travel cost and travel time into a single variable. A disadvantage to this procedure is the fact that the researcher must still assign one or more specific trade-offs between monetary cost and travel time.

Brown and Nawas (1973) attempted to separate the monetary costs from the non-monetary costs. They found that the standard errors for the coefficients of the distance traveled and travel costs were reduced by using individual observations. However, some recent research indicates some problems associated with the individual observation approach, including bias from measurement error (Brown, Sorhus, Chou-Yang, and Richards, 1980).

Given the importance of including time in the model, it was necessary to obtain a different formulation for the time variable. Oscar Burt (at the annual WAEA/AAEA meetings in Pullman, Wash. 1979) suggested expressing travel time in monetary terms by multiplying the round trip travel time by the respondent's hourly income, thus creating an opportunity cost of time variable. This new variable could then be included in the regression equation as an opportunity cost of travel time. In research by Sorhus (1981) the multiplication of the respondent's wage rate by the travel time reduced the correlation between opportunity cost of travel time and travel cost to reasonable levels, thus increasing the efficiency of both explanatory variables and at the same time reducing specification bias.

Its failure to consider substitutes is a further limitation of the simple travel-cost method of estimating net economic value. The greater the distance a zone is from a particular recreational site, the greater are the number and appeal of available substitutes for that particular site, because other sites become relatively cheaper in time and money.

The travel-cost method has been critized as being an empirical procedure relying on the tendency for large groups to have uniform behavior such that the aggregation of the responses of a large number of people results in an average (Edwards, Gibbs, Guedry, and Stoevener, 1976). Dwyer, Kelly, and Bowes (1977) on the other hand argue that its clear theoretical base is the reason that it is usually used.

Before discussing the statistical and economic model in this study, a description of the questionnaires and procedures used in the survey of Oregon big game hunters should first be presented.

III. SOURCE OF DATA

Sampling Procedures

As indicated by Brown, Nawas, and Stevens (1973, p. 13), the Oregon State Game Commission (now the Oregon Department of Fish and Wildlife) supplied the names and mailing addresses of about 17,000 Oregon licensed hunters, which were grouped into six blocks according to the last two digits of hunting licenses sold in 1966. These six blocks constituted the sample for their survey, "Annual Hunting Inventory," which had been conducted since 1950 to secure a gross measure for all types of hunting. They had selected randomly six two-digit numbers between 1 and 100, namely 10, 34, 38, 66, 78, and 94. All hunting licenses sold in 1966 and ending with 10 formed Block #1, those ending with 34 formed Block #2, etc.

Block #1 and part of Block #2 were selected randomly to form our sample for the Oregon Big Game Study. Our sample was about 3,000, or roughly one percent of the licensed big game hunters in the State. This sample necessarily excluded hunters who started hunting in 1967 or 1968. Some bias may result from this procedure, but the 1966 address cards were the only ones available for sampling.

Two questionnaires were mailed to hunters in 1968. The first concerned the investment by the hunter and his family in hunting and associated equipment. This questionnaire was mailed early in August 1968. The second questionnaire was a big game hunting trip record in which the hunter was asked to record his hunting trips.

Since the research in this thesis is based upon the data from the second questionnaire, the hunting trip record, it is shown in Table 1. Identical "follow-up" procedures were used for both questionnaires. First and second reminders were mailed if the earlier questionnaires were not returned. More details concerning the sampling procedures are given by Brown, Nawas, and Stevens (1973).

Oregon Game Commission data indicated that there were 363,000 licensed hunters in Oregon in 1968. Based upon additional research, our sample indicated that 4.4 percent of the licensed hunters were non-big game hunters; thus, estimated number of big game hunters in Oregon were

$$363{,}000 \times 95.6 \;=\; 347{,}000.$$

Furthermore, the survey data indicated an average of 1.86 licensed hunter per family, which make the number of hunting families in Oregon equal to 186,000. Additional research showed that around 84.16 percent of the licensed hunters went hunting for big game in 1968, so the number of families hunting big game would be

$$186{,}000 \times .8416 \;=\; 157{,}000.$$

It should be noted that although the original survey data indicated 1.86 licensed hunters per family, only 1.752 persons per family actually hunted on the hunting trips, on the average. Therefore, the blow-up factor to compute the total hunting days was calculated as follows: Dividing the total number of families hunting big game (157,000) by the number of hunting families in our sample (552) gives the estimated blow-up factor of 284.42. Similarly, multiplying the family hunting days observed from our sample (4,066) by average number of persons per family

1968 BIG GAME HUNTING TRIP RECORD

Budget Bureau No. 42—S67008
Approval Expires July 1969

1. This record is designed to help you and other family members, who are presently residing at home, keep track of 1968 Big Game hunting trip expenses. Please record the information under each column heading for each hunting trip, in Oregon, family members take for deer, elk, or other Big Game during any of the 1968 hunting seasons.

After your LAST Oregon hunting trip of the 1968 season, be sure to complete the back side of the page, then seal the record sheet so that the mailing address is on the outside, and mail it at your earliest convenience.

		1st Trip	2nd Trip	3rd Trip	4th Trip	5th Trip	6th Trip	7th Trip	8th Trip	9th Trip	10th Trip	11th Trip	12th Trip
List number of days spent on hunting trip, including travel time:													
How many family members?	Went on trip												
	Hunted on trip												
On this trip list total hours all members of family, counted together, spent hunting for:	Deer												
	Elk												
	Other (Specify)												
Number of Big Game animals bagged by your family on trip:	Deer												
	Elk												
	Other (Specify)												
Oregon Game Commission unit or area hunted on trip:													
TRANSPORTATION	Miles traveled from home to hunting site & back												
	Hours spent traveling from home to hunting site and back												
	Miles traveled while on hunting site, by vehicle												
	Amount, if any, paid to you by others for transportation $												
	Amount, if any, you paid to others for transportation $												
EXPENDITURES	Motels, hotels, camping or private hunting fees $												
	Ammunition, arrows, & broadheads $												
	Food, beverages & liquor on hunting trip $												
	Guide service & rental of horses, airplanes, or other vehicles $												
	Cutting & wrapping meat, tanning hides $												
	Other expenses incurred on hunting trip $												

(Please continue questionnaire on other side)

2. Please list the number of 1968 Oregon Big Game tags or licenses purchased by members of your family who are presently residing at home:

Hunter's or combination angler's & hunter's licenses........................	Resident..................	Non-Resident..................
General deer tags	Resident	Non-Resident..................
Controlled season deer tags		....
General elk tags	Resident..................	Non-Resident..................
General antelope tags		....
Other tags (Please specify)		....

3. Is there anything else that you would like to tell us?

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1968 HUNTING TRIP RECORD

actually hunting (1.752) gives

$$4,066 \times 1.752 = 7,123.6.$$

7,123.6 is the total person hunting days observed from the sample. Thus, the total hunting days for all Oregon hunters would be

$$7,123.6 \times 284.42 = 2,026,000.$$

This estimate of about two million hunting days is surprisingly close to the total hunting days of 1,965,000 reported by the Oregon State Game Commission (1969).

Information about number of trips, variable cost, location of home, and where they hunted was gathered from the second questionnaire. The total number of deer and elk harvested and the total days of hunting for 1968 were taken from the Oregon Game Commission Annual Report (1969). The proportion of private land to public land in Oregon and the population of each county in Oregon were obtained from the U.S. Bureau of Census.

IV. ANALYTICAL ISSUES IN THE ESTIMATION OF OUTDOOR RECREATION DEMAND FUNCTIONS

In the usual formulation of the travel-cost method, all observations from a given distance zone are averaged into a single value for each variable. In a situation such as for Oregon big game, there tends to be a large number of observations for the distance zones which are closest and for those which have large populations relative to those distance zones which are less populated and further away.

To use the data in this form would be inefficient since zones with few observations could be given the same weight as zones with many observations. To avoid this problem, each distance zone was divided into a number of subzones that contained approximately the same number of observations.

Specification of the Dependent Variable

As mentioned by Brown, Sorhus, Chou-Yang, and Richards (1980), the use of individual observations for fitting a travel cost-based outdoor recreational demand function will provide a properly identified demand function only if each observation is divided by its proper proportion of population. Thus, the dependent variable, participation rate, needs to be expressed on a per capita basis, just as when using the traditional zone averages for fitting the travel cost demand funtion. If the dependent variable is not defined in terms of per capita participation, then erroneous results may be obtained because such a procedure would not properly account for the lower percentage of people participating in the recreational activity from the more distant zones.

The preceding remarks are illustrated by a simple hypothetical example in Table 2. For the example, it is assumed that a small sample has been drawn from users of a recreational site. For simplicity, it is assumed that there are no entrance fees or on-site costs. If the traditional zone average visits per capita, next-to-last column in Table 2, is fitted as a function of travel cost, then $\hat{q}_i = 10 - 2\ TC_i$, where TC_i denotes the travel cost for distance zone i and $\hat{q}_i$ denotes the estimated per capita participation rate. Computing the definite integral of the demand function for each distance zone gives a per capita consumers' surplus of \$16, \$9, and \$4 for distance zones 1, 2, and 3, respectively. Multiplying these per capita values by the respective main zone populations in Table 2 gives a total consumers' surplus of \$48,000 + \$31,500 + \$18,000 = \$97,500.

It needs to be noted that if the individual sample observations, third column in Table 2, are used as the dependent variable and TC_i is the explanatory variable, the equation $Q^*_{ij} = 9 - TC_{ij}$ would be obtained. However, this equation is not valid to use for estimating participation rates and consumers' surplus. If this equation were to be integrated to estimate consumers' surplus, an erroneous estimate of \$32, \$24.5, and \$18 per person would be obtained for distance zones 1, 2, and 3, respectively. Multiplying these values by the respective main zone populations in Table 2 gives a total consumers' surplus of \$262,750.

If a valid estimate of the underlying demand structure is to be estimated from the individual observations, then each observation needs to be expressed on a per capita basis, just as for the traditional travel-cost model. To properly define the dependent variable in terms of a per

Table 2. Hypothetical Observations and Distance Zones for Illustrating the Estimation of a Travel Cost Recreational Demand Function by Individual Versus Zone Averages

Main distance zone$_i$	Main zone population	Annual visits per observed person	Average travel cost per visit	Estimated total number of visits a/	Zone average visits per capita	Individual observed visits per capita
		6	$1	6,000		6
1	3,000	8	$1	8,000	8	8
		10	$1	10,000		10
		5	$2	5,000		4.2857
2	3,500	7	$2	7,000	6	6.0000
		9	$2	9,000		7.7143
		3	$3	3,000		2
3	4,500	6	$3	6,000	4	4
		9	$3	9,000		6

a/ Assumes a sampling of 0.1 percent and corresponding blow-up factor of 1,000.

capita participation rate, perhaps the most stratightforward procedure is to first expand each observation by the inverse of the sampling rate (as shown in column 5 of Table 2), then divide by the appropriate share of the main distance zone's population. In Table 2, each individual observation was multiplied by a blow-up factor of 1,000, then divided by one-third of the main distance zone population to transform the individual observations to "individual observed visits per capita", last column of Table 2. Using the numbers in the last column of Table 2 for the dependent variable, a valid estimate of the demand function, $q_{ij} = 10 - TC_{ij}$, is obtained, and the same total consumers' surplus computed as for the previous traditional zone average travel-cost model.

Efficient Estimation of Travel-Cost Model With Unequal Zonal Population

An important development in the estimation of recreational benefits using the travel-cost method was presented by Bowes and Loomis in 1980. They noted that "The use of ordinary least squares does not lead to desirable estimates of per capita demand curves when the researcher forms samples of varying sizes from each zonal area of observation."

"In preliminary estimation of simple linear first stage demand curves, using trips per capita as the dependent variable and round trip travel costs as the independent variable, practitioners often find the estimated number of trips at a zero fee grossly above or below the actual number observed. However, with a little thought, it becomes apparent that the real problem is not the misestimation of total visits, for our concern is with adequate estimation of benefits. The estimate of benefits derived through ordinary least squares (OLS) estimation of per capita demand is unbiased, even if visits are grossly mispredicted. The needed correction is one of adjusting for the heteroskedasticity introduced by the different population sizes in each zone. This is easily accomplished and has the virtue of reducing the variance of the estimates of demand parameters and benefits while preserving unbiasedness. In addition, the correction guarantees the exact prediction of visits at actual price."

"Establishing the first stage demand curve using OLS implies weighting the sample observation from each origin equally in determining the regression line. This weighting pattern is justified only if the variances for the observations on average per capita visitation rates are equal for each origin. That this assumption about the variances is not justified can be demonstrated as follows. If the variance of the individual's visitation rates, $Var(v_i) = \sigma^2$ and all visits are observed, then the variance of the mean visits per capita from the zone is $Var(V_i) = \sigma^2/Ni$, where N is the zone population. Specifically, the larger the origin's population (Ni), the smaller the variance of the visits per capita variable. These unequal variances result in heteroskedasticity in the demand curve estimation process."

"The well-known solution is to weight the trips per capita and travel costs for each origin. Assuming, as we did above, that the variance of the individuals' visitation rate is constant across all origins, the weighting factor is the square root of the origins' population. The new weighted observations, $V_i \sqrt{N_i}$ will then have equal variances of $Var(V_i \sqrt{N_i}) = N_i Var(V_i) = \sigma^2$. The resulting ordinary least squares estimates of such weighted observations are equivalent to generalized least square (GLS) estimates."

"Utilizing this "corrected" form to estimate the per capita demand curve results in predicted number of trips at a zero price exactly equal to actual number of trips. Also, as is well known, this GLS estimate will provide the minimum variance estimator among the class of linear unbiased estimators, and has the same properties for the estimation of benefits when these are measured as the area under the average demand curve above travel cost and up to an arbitrary price level."

V. ESTIMATION OF DEMAND FUNCTIONS FOR OREGON BIG GAME

The Linear Demand Function

Before presenting the estimated linear demand equations, it should be noted that the data were grouped into five geographical areas, which corresponded to the administrative regions of the Oregon Game Commission. The location of these five administrative regions, and the game management units within each region, are shown in Figure 2. The demand analysis for this thesis will be concerned only with the Northeast region and the Central region due to money and time constraints. However, these two regions are by far the most important hunting areas of Oregon. These two regions accounted for over 74 percent of the estimated net economic value (Brown, Nawas, and Stevens, p. 93).

The Northeast Oregon region has some of the finest hunting in the United States. During the 1968 hunting season, over 45,000 mule deer were harvested in Region IV and almost 6,000 Rocky Mountain elk, according to the 1969 Annual Report of the Oregon State Game Commission. The Central Oregon hunting area is similar to Northeast Oregon in that many hunters came to hunt from outside the area, especially from Northwest Oregon. Hunters harvested 26,400 deer, and 108 elk in the Central region, according to the 1969 Annual Report.

The 640 hunting family observations obtained by a 1968 survey mentioned earlier in Chapter III, were divided into 126 distance zones with five observations per zone, on the average. The reason for averaging five observations per zone was to make the zones small enough to obtain a good

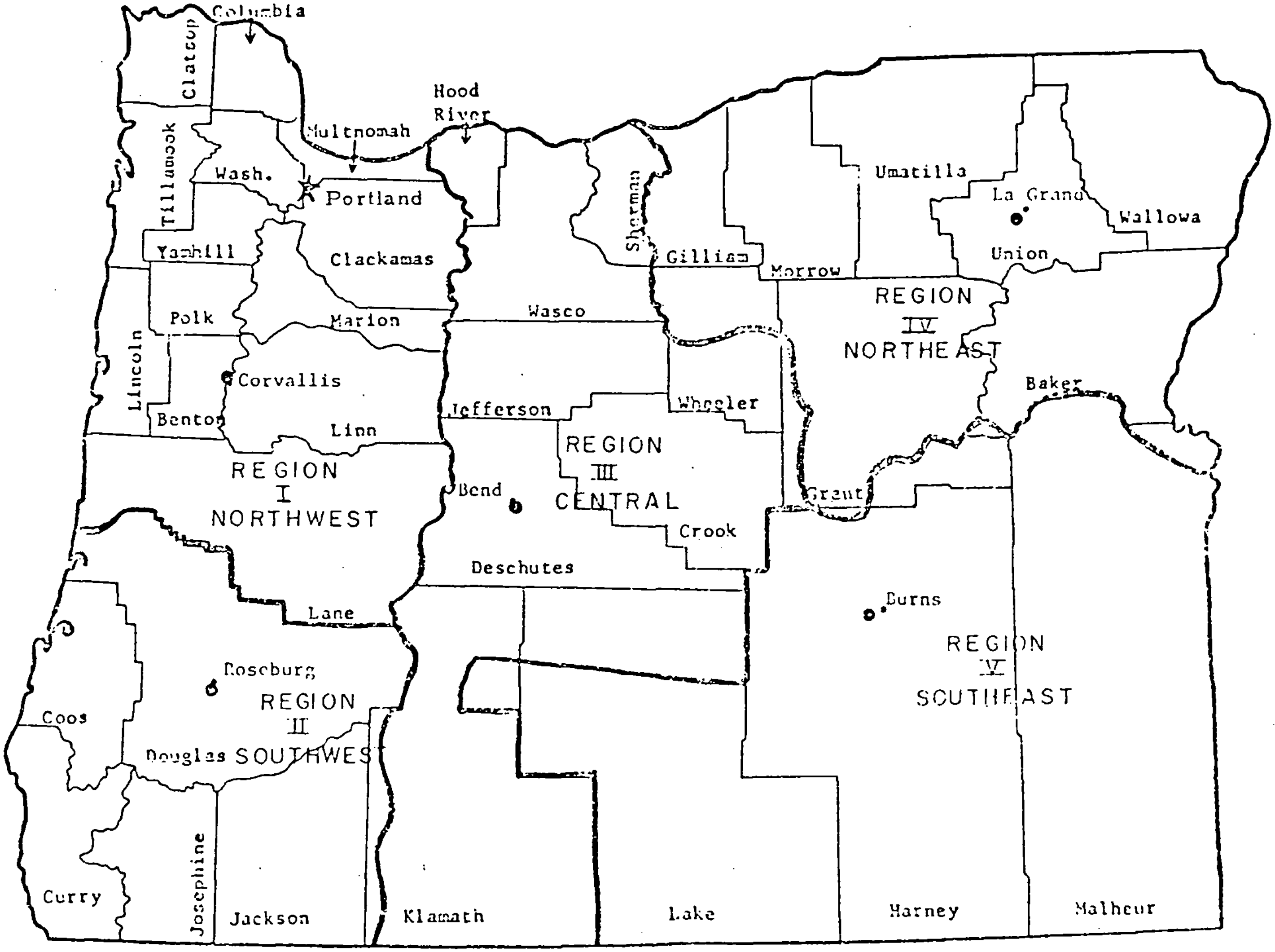

FIGURE 2. OREGON GAME COMMISSION ADMINISTRATIVE REGIONS

geographical dispersion of distance zones throughout the state. As discussed in the preceeding chapter, using zone averages instead of individual observations has the advantage of reducing bias from measurement error in the explanatory variables.

As mentioned earlier, non-monetary costs of distance are hypothesized to be an important shifter of the outdoor recreational demand function (Cesario and Knetsch, 1970). Consequently, one reason for constructing the distance zones was to obtain a measurement of the important travel time effect. To obtain a variable to reflect the effect of travel time, we computed the average one-way highway distance traveled by the hunting families in a given zone to the nearest edge of either the Northeast or Central hunting region, depending upon where they hunted. This procedure gave somewhat better results than using the average distance travelled by the hunters of each zone. Hunters of distance zones falling within the Northeast or Central region were assigned distance values of zero.

Fitting the data by the Bowes-Loomis suggested generalized least squares model, discussed in the preceeding chapter, the following equation was obtained.

<u>The Unconstrained Function</u>

$$(1)\quad \hat{Y}_{ij}\sqrt{POPN_i} = \underset{(0.06282)}{0.1898}\sqrt{POPN_i} - \underset{(0.00009637)}{0.000571}\ DIST_{ij}\sqrt{POPN_i}$$

$$- \underset{(0.0001953)}{0.00027404}\ TC_{ij}\sqrt{POPN_i} - \underset{(0.07201)}{0.2944}\ PRVT_i\sqrt{POPN_i}$$

$$+ \underset{(0.00001255)}{0.00004106}\ ELK_j\sqrt{POPN_i} + \underset{(0.000002245)}{0.000000682}\ DEER_j\sqrt{POPN_i}$$

$R^2 = 0.4303$

$n = 126$

$d = 1.23$

Numbers in parenthesis below coefficients are standard errors.

In Equation (1),

$\sqrt{POPN_i}$ refers to the square root of the population of the i^{th} distance zone;

$\hat{Y}_{ij}$ denotes the hunting trips per capita of distance zone i to the hunting region j;

$DIST_{ij}$ is the average one-way distance from distance zone i to hunting region j;

TC_{ij} is the average hunting expenses per trip by hunters from distance zone i to hunting region j;

$PRVT_j$ is the proportion of private land to public land in hunting region j;

ELK_j is the number of elk harvested in region j (Oregon State Game Commission, 1969);

$DEER_j$ is the number of deer harvested in region j (Oregon State Game Commission, 1969).

It should be noted that the travel cost coefficient in equation (1) is low compared to the distance coefficient due at least partly to the high correlation between them, $r = 0.93$. The distance coefficient is approximately 2.10 times the travel cost coefficient which implies that each added mile of one-way distance between hunters' residence and the hunting region reduces hunting to the same extent as an increase in travel cost of $2.10. This non-monetary cost of travel time seems far too high if we assume that hunters travelled 40 miles per hour in 1968.

Dividing 40 miles per hour by two miles (round trip) implies that only three minutes of travel time would be required per mile of one-way distance. But \$2.10 divided by three minutes gives \$0.70, an estimated cost of travel time per minute or \$42 per hour. Since the average income of hunters in 1968 was only about \$8,000 (Brown, Nawas, Stevens, p. 27), an average work load of 2,000 hours per year would imply an average wage rate of only \$4 per hour. Thus, the implied effect of travel time seems too high. A more reasonable estimate of the cost of travel time would appear to be as follows.

As noted above, if hunters averaged 40 miles per hour, then the round-trip travel time would be three minutes per mile of one-way distance. At the \$4 per hour wage rate, this would represent a cost of (3/60) times \$4 ≐ \$0.20. However, from our sample data, an average of about 1.75 hunters per family actually hunted per hunting trip. If so, the loss in wages would be about (\$0.20) times 1.75 ≐ \$0.35 per mile of one-way distance. Based upon this estimate of cost of travel time, the distance coefficient was constrained to be equal to only 0.35 of the travel cost coefficient. (This represents a constrained cost of travel time equal to \$0.35 per mile of one-way distance since travel costs were measured in dollar units.) Equation (1) was then refitted with the above constraint on the distance coefficient.

The Constrained Function

$$(2)\quad \hat{Y}_{ij}\sqrt{POPN_i} = \underset{(0.6293)}{0.1294}\sqrt{POPN_i} - \underset{(0.0001304)}{0.0002763}\ DIST_{ij}\sqrt{POPN_i}$$

$$- \underset{(0.0001304)}{0.0007895}\ TC_{ij}\sqrt{POPN_i} - \underset{(0.07217)}{0.1355}\ PRVT_j\sqrt{POPN_i}$$

$$+ \; 0.000297 \; ELK_j \sqrt{POPN_i} \; + \; 0.000002298 \; DEER_j \sqrt{POPN_i}$$
$$(0.00001263) \qquad\qquad (0.0000022903)$$

$R^2 = 0.381$

$n = 126$

$d = 1.21$

Equation (2) was considered to be preferable to (1), especially given the greater precision indicated for the travel cost variable. (The travel cost variable is important because the estimated net economic value to the hunters depend crucially upon the coefficient of this variable.) All the variables that were significant in Equation (1) are still significant in Equation (2). There was a small drop in R^2 in Equation (2) due to the reduction in the number of explanatory variables from combining the distance and the travel cost into one variable to correct the high correlation between them in Equation (1). The drop in R^2 from 0.4304 to 0.381 was not significant at the five percent probability level, as shown in Table 3.

TABLE 3. F-Test to Indicate Whether the R^2 for Constrainted Equation (2) was Significantly Reduced

Source	Degrees of Freedom	Sum of Squares	Mean of Squares
Residual from the constrained demand function	121	33,230	282.9
Residual from the unconstrained demand function	120	32,170	274.9
Difference	1	1,060	

$F^1_{121} = 1060 \div 282.9 = 3.75$, which is less than tabulated F^1_{120} for the five percent level.

The constraint on the distance coefficient (to be 0.35 times the travel cost coefficient) made the coefficients of the explanatory variables to be more reasonable in Equation (2), especially for the case of the $DEER_j$ coefficient. The $DEER_j$ coefficient increased from 0.000000682 in Equation (1) to 0.000002298 in Equation (2). For this and earlier discussed reasons, Equation (2) was chosen over Equation (1) to estimate net economic value for the Oregon big game.

The Exponential Demand Function Fitted by Logarithmic Transformation

The linear model of the preceeding section can be criticized because it can be argued that the demand curve should not be linear. Although several algebraic forms of the demand function could satisfy the curviliness property, the exponential function is one of the most convenient to employ. Sometimes the double logarithm function has been used. However, the assumption of constant elasticity itself is rather restrictive. With the double log function, meaningful estimates of consumers' surplus cannot be computed, unless one imposes some arbitrary upper bound upon travel cost. Therefore, we fitted the exponential function:

$$(3) \quad Y = \exp\,[\beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_K X_K]$$

which has the advantage of variable elasticity of demand and a finite consumers' surplus as travel cost tends to infinity.

The exponential function is convenient to fit by ordinary least squares by means of logarithmic transformation. However, the Bowes-Loomis generalized least squares (GLS) transformation is no longer simple to apply because of the logarithmic transformation of the variables and the error term. For one thing, before the logarithmic transformation, the error term would have to be assumed to be multiplicative. Other special assumption would also have to be made before one could determine the proper GLS relationships involved. Because of all these complications, only OLS was used to fit the exponential demand function in the form.

$$(4)\quad \ln\hat{Y}_{ij} = \hat{\beta}_0 + \hat{\beta}_1\ DIST_{ij} + \hat{\beta}_2\ TC_{ij} + \hat{\beta}_3\ PRVT_j + \hat{\beta}_4 ELK + \hat{\beta}_5\ DEER_j$$

Coefficients for the resulting regression is presented first for the unconstrained function.

<u>The Unconstrained Demand Function</u>

$$(5)\quad \ln\hat{Y}_{ij} = \underset{(0.6436)}{-2.0799} - \underset{(0.0008294)}{0.009509}\ DIST_{ij} - \underset{(0.002341)}{0.007483}\ TC_{ij} - \underset{(0.6646)}{2.5701}\ PRVT_i$$

$$+ \underset{(0.0001265)}{0.0004722}\ ELK_j + \underset{(0.00002846)}{0.00007196}\ DEER_j$$

$R^2 = 0.7114$

$n = 126$

$d = 1.495$

Numbers in parentheses below coefficients are standard errors. Note that in Equation (5) the distance coefficient is approximately 1.30 times the travel cost coefficient which implies that each added mile of one-way distance between the hunters' residence and the hunting region reduces hunting to the same extent as an increase in travel cost of $1.30. Based upon the estimate of the cost of the travel time from the preceeding section, the distance coefficient was constrained to be equal to only 0.35 of the travel cost coefficient. Equation (5) was then refitted with the above constraint on the distance coefficient.

The Constrained Demand Function

$$(6)\ \ln Y_{ij} = \underset{(0.6959)}{-\ 2.040} - \underset{(0.001098)}{0.006038}\ DIST_{ij} - \underset{(0.001098)}{0.01725}\ TC_{ij} - \underset{(0.7186)}{2.606}\ PRVT_j$$

$$+ \underset{(0.0001368)}{0.0004796}\ ELK_j + \underset{(0.00003069)}{0.00008100}\ DEER_j$$

$R^2 = 0.695$

$n = 126$

$d = 1.663$

Due to the constraint on the distance coefficient, the travel cost coefficient was highly significant as was expected with a value of t of nearly 16.

Note that in Equation (6), the other coefficients of the explanatory variables stayed about the same compared to the coefficients in unconstrainted Equation (5). The reduction in R^2 was not significant at the five percent probability level, as shown in Table 4.

TABLE 4. F-Test to Indicate Whether the R^2 in Constrainted Equation (6) was Significantly Reduced

Source	Degrees of Freedom	Sum of Squares	Mean of Squares
Residual from the constrained demand function	121	70.5	0.583
Residual from the uncontrained demand function	120	68.7	0.552
Difference	1	1.8	

$F^1_{121} = 1.8 \div 0.583 = 3.09$, which is then tabulated F^1_{120} for the five percent level.

The net economic value of the Oregon big game resource from the exponential function was estimated by using Equation (6). If we look at Equation (6) versus Equation (2), one point that should be noted here is that the estimated coefficients for the two variables, $DEER_j$ and ELK_j, were more reasonable in Equation (6) than in (2). The coefficients of the two variables in Equation (2) imply that one elk was worth about thirteen deer, whereas in Equation (6), the coefficients of the two variables indicate that one elk was worth about six deer, which seems to be a more reasonable estimate.

Since estimates of the net economic value depend upon reliable estimates of structural coefficients, the results from the exponential function were judged to be satisfactory for the projected changes in the net economic value of the Oregon big game resource from changes in projected harvest of deer and elk. (These results will be presented in the next chapter.)

VI. NET ECONOMIC VALUE OF THE OREGON BIG GAME RESOURCE

Once the demand function has been properly specified and estimated, it is relatively simple to compute the net economic value. The consumer surplus concept was used to estimate the net economic value of Oregon big game because some researchers consider it to be a more valid measure of net economic value (Dwyer, Kelly, and Bowes).

Estimation of Net Economic Value from the Linear Demand Function

Estimation of consumers' surplus for each zone is equivalent to computing that area lying beneath the demand curve but above the transfer costs necessary for participation. Equation (2) was used to compute the consumers' surplus for each zone. Summing the consumers' surplus for each of the 126 zones gave a total estimated net economic benefit of approximately $11 million, as shown in Table 5. Dividing the total estimated net economic value by the total number of hunter days gave an average net economic value of $\$11{,}010{,}000 \div 1{,}035{,}890 \doteq \$10.63$ per day.

Table 5. Estimation of Net Economic Value for the Northeast and Central Hunting Regions of Oregon, Based Upon the Linear Demand Function

Region	Consumers' Surplus
Central Region	$ 3,245,000
Northeast Region	7,765,000
Total	$11,010,000

Estimated Net Economic Value from the Exponential Demand Function

As discussed in the previous chapter, the exponential demand function had certain logical advantages over the linear demand function. Also, the exponential function appeared to give a better fit (higher R^2 values) for both the unconstrained and the constrained functions (the R^2 values are not entirely comparable between the linear versus the exponential functions since the R^2 for the linear function is in terms of the real numbers while R^2 for the exponential is in terms of the logarithms of the dependent variable).

The consumers' surplus concept was used here again because it is a better measure of net economic value, as recommended by Dwyer, Kelly, and Bowes, 1977. Consumers' surplus values were obtained from different zones by integrating

$$(7) \quad CS_{ij} = \int_{TC_{ij}}^{\infty} a_{ij} e^{\hat{\beta} TC_{ij}} dTC_{ij}$$

where a_{ij} varies from zone to zone, depending upon the other explanatory variables in the demand equation. Equation (7) reduced to the predicted Y_{ij} divided by the absolute value of the travel cost coefficient. Computing the consumers' surplus per capita for each zone, then multiplying by the zone population, the total consumers' surplus for each zone of the 126 zones gave a total estimated net economic value of approximately \$14.3 million as shown in Table 6. Dividing the total estimated net economic value by the total number of hunter days (Oregon State Game Commission, 1969) gave an average of \$14,301,000 ÷ 1,035,890 ≐ \$13.81.

Table 6. Estimates of Net Economic Value for the Northeast and Central Hunting Regions of Oregon, Based Upon the Exponential Demand Function

Region	Consumers' Surplus
Region III, Central Oregon	$ 5,335,000
Region IV, Northeast Oregon	8,966,000
Total	$14,301,000

Estimation of the net economic value of Oregon big game hunting makes it possible to compare the economic value of this non-marketed commodity with other resource uses. In particular, the monetary value for big game hunting may be useful for management decisions in those cases where big game animals are competitive with commercial timber production and/or domestic livestock grazing. The estimates may also be useful in allocating investment funds among regions. For example, with knowledge of net economic value the policy makers could allocate funds to each region according to the willingness of hunters to use their own resources in order to hunt big game. The measures of "net economic value per animal harvested" and "net economic value per hunter day" in Table 7 both suggest that the Northeast region is identified as that region where the first funds should be invested. On the average, the values figures imply that hunters would be willing to pay $175 per big game animal harvested in the Northeast region versus $140 in the central region, based upon the exponential demand function. Alternatively, they would be willing to pay an average of $152 per big game animal harvested in the Northeast region versus $85 in the Central region, based upon the linear demand function as shown in Table 8. However, one limitation of net economic value per hunter day and per animal

Table 7. Alternative Criteria for Investment

Net Economic Value per Animal Harvested

Region	Net Economic Value [a]	Harvest [b] Deer	Elk	Total	Net Economic Value per Animal Harvested
Northeast	8,966,000	45,260	5,855	51,115	$175.41
Central	5,335,000	37,870 [c]	108	37,978	140.48
Total	14,301,000	83,130	5,963	89,093	$160.00

Net Economic Value per Hunter Day

Region	Net Economic Value [a]	Hunter Days [b] Deer	Elk	Total	Net Economic Value per Hunter Day
Northeast	8,966,000	325,900	272,570	598,470	$14.98
Central	5,355,000	429,150	8,270	437,420	12.20
Total	14,301,000	755,050	280,840	1,035,890	$13.81

a/ Consumers' Surplus from exponential function.

b/ Oregon State Game Commission, 1969 Annual Report.

c/ Game Management units of Fort Rock, Interstate, and Silver Lake were included in the Central region.

harvested in Table 7 and Table 8 is that the deer and elk are averaged together, which partly accounts for the higher value for the Northeast region, since the harvest in this region consists of a higher percentage of elk.

It should be noted that these net economic values of the Oregon big game resource were higher than the values that had been computed earlier by Brown, Nawas, and Stevens (1973), p. 95. The higher estimated values appear to be due to the better specification of the dependent variable and the addition of the deer and elk harvest as explanatory variables. As mentioned earlier in Chapter IV, the dependent variable was expressed on a per capita basis. If the dependent variable is not

Table 8. Alternative Criteria for Investment

Net Economic Value per Animal Harvested

Region	Net Economic Value [a]	Harvest [b]			Net Economic Value per Animal Harvested
		Deer	Elk	Total	
Northeast	7,765,000	45,260	5,855	51,115	$151.91
Central	3,245,000	37,870 [c]	108	37,978	85.44
Total	11,010,000	83,130	5,963	89,093	$123.58

Net Economic Value per Hunter Day

Region	Net Economic Value [a]	Hunter Days [b]			Net Economic Value per Hunter Day
		Deer	Elk	Total	
Northeast	7,765,000	325,900	272,570	598,470	$12.97
Central	3,245,000	429,150 [c]	8,270	437,420	7.42
Total	11,010,000	755,050	280,840	1,035,890	$10.63

a/ Consumers' Surplus from linear function.

b/ Oregon State Game Commission, 1969 Annual Report.

c/ Game Management units of Fort Rock, Interstate, and Silver Lake were included in the Central region.

defined in terms of per capita basis, then biased results may be obtained because such a procedure would not properly account for the lower percentage of people participating in the recreational activity from the more distant zones.

Net economic value per animal harvested, averaged for both regions, was $160 (from Table 7), and this value is in 1968 dollars. Each dollar of 1968 is worth approximately $2.47 in 1980. However, one cannot infer that the net economic value per animal harvested is $2.47 times as high as in 1980 dollars, even though the Consumer Price Index rose from 104.2 in 1968 to 246.8 in 1980 with 1967 used as a base of 100. Hunting patterns and travel costs may have changed greatly since 1968.

Another point that should be noted with regard to Tables 7 and 8 is that the number of elk harvested in the central region in 1968 was only 108 versus 5,855 harvested elk in the Northeast region. To obtain an indirect estimate of the value of elk, the following steps can be followed using Table 7. By multiplying the net economic value per animal harvested in the central region ($140.48) times the number of deer in the Northeast region (45,260) gives $6,358,000, which is an estimate of the value of deer in the Northeast region. Subtracting this net economic value of deer for the Northeast region (6,358,000) from the total value of all big game in that region ($8,988,000) gives an estimated value for elk of $2,607,875. Dividing the $2,607,875 by the number of elk harvested in the Northeast region (5,855) gives an average value of elk of $445.41, assuming that the value of deer in the two regions is the same.

Projected Changes in Net Economic Value from Changes in Harvest of Deer and Elk

As mentioned earlier in Chapter I, a conflict arises between different groups concerning management decisions when big game competes with commercial timber production and/or domestic livestock grazing. Hunters and conservation groups on one hand tend to favor management practices that would lead to larger deer and elk numbers. On the other hand, ranchers and foresters would tend to favor management practices leading to lower deer and elk numbers.

The economic impact of different deer and elk harvest policies in Eastern Oregon have in the past been uncertain because the economic effect of smaller or larger harvest of game animals has not been investigated before. However, Equation (6) allows an estimate of the change in net economic value associated with changes in big game harvest. In this study an attempt is made to look at the change in the net economic value of the big game resource from an increase of ten percent in the number of deer and elk harvested, as shown in Table 9. the change in net economic value would be obtained as follows.

The number of deer harvested in 1968 for the first hunting region in the Northeast was 22,960. A ten percent increase would be 2,296. By multiplying 2,296 times 0.000081 (the deer coefficient from Equation (6)) gives a value of 0.185976. Taking the antilogarithm of 0.185976 gives a value of 1.2044, which implies a 20.4 percent increase in participation and consumers' surplus for the first hunting region. Multiplying 1.2044 times the original consumers' surplus for that hunting region gives the new consumers' surplus. Following the above procedure for each region, the new consumers' surplus for the assumed increase in deer and elk was computed, as shown in Table 9.

As shown in Table 9, the consumers' surplus in the Northeast region increased by 20.2 percent from the assumed ten percent increase in the number of deer harvested. An increase of 15.3 percent in net economic

Table 9. Projected Changes in Net Economic Value from Changes in Harvest of Deer and Elk a/

	Estimated Consumers' Surplus with 1968 Harvest	Estimated Consumers' Surplus with a 10% Increase in the Number of Deer or Elk Harvested	
Region	Harvest	Deer	Elk
Northeast	$8,966,000	10,776,000	10,334,000
Central	5,335,000	6,041,000	---

a/ Based upon the exponential demand function, Equation (6).

value was predicted as a result of the ten percent increase in the number of elk harvested. For the central region the consumers' surplus increased by 13.2 percent from the assumed ten percent increase in the number of deer harvested. In the central region, there were too few elk harvested in 1968 (108) to permit a meaningful projection from an increase of elk. The 20.2 percent increase in consumers' surplus from a ten percent increase in the number of deer harvested in the Northeast region seems somewhat too high.

A more reasonable increase in consumers' surplus would be an increase in the same proportion as the increase in the number of deer harvested, such that the percent change in the predicted value of the consumers' surplus is the same as the percent change in deer numbers. To test this hypothesis of equal change, the following steps should be followed.

Recall that the original Equation (6) was of the following form:

$$(8) \quad Y = e^{\hat{\beta}_o + \ldots + \hat{\beta}_5(\text{Deer})}.$$

It should also be recalled from Equation (7) that the estimated consumers' surplus, based upon the exponential demand function, increases or decreases exactly as the predicted quantity, $\hat{Y}$, increases or decreases. Therefore, the more reasonable desired coefficient for the effect of increased deer numbers can be computed from the following relationships. Suppose that deer numbers are increased by Δ percent. Then, a coefficient for deer increase is desired such that $\hat{Y}$ (and consumers' surplus) also increases by Δ percent. That is let

$$(9) \quad CY = e^{\hat{\beta}_o + \ldots + \hat{\beta}_5\text{Deer} + \hat{\beta}_6^{*} \Delta \text{ Deer}}$$

where β^* is the desired coefficient for the effect of the increase in deer numbers and C = (1 + Δ). For delta = 0.1, then

(10) $(1+0.1)\ \hat{Y} = e^{\hat{\beta}_o + \dots \hat{\beta}_5 \text{Deer}} \cdot e^{\hat{\beta}^*_6 (0.1\text{Deer})} = \hat{Y}\ e^{\hat{\beta}^*_6 (.1\text{Deer})}.$

Dividing both sides by $\hat{Y}$ implies that

(11) $1.10 = e^{\hat{\beta}_6 (2,296)}$

where 2,296 is the ten percent increase in the number of deer harvested in the first hunting region of the Northeast. Taking the logarithm of both sides of Equation (11) gives

(12) $\ell n\ (1.10) = 0.09531 = 2,296\ \hat{\beta}^*_6.$

Therefore, $\hat{\beta}^*_6$ will equal 0.09531 ÷ 2,296 ≐ 0.0000415. This desired coefficient of 0.0000415 will yield a ten percent increase in consumers' surplus from a ten percent increase in the number of deer harvested.

To test the hypothesis that this desired coefficient is not significantly different from the original OLS coefficient for deer, $\hat{\beta}_5$, a t-test was made as follows:

Substracting the desired deer coefficient (0.0000415) from the original deer coefficient (0.000081) gives a value of 0.0000395. Dividing the value 0.0000395 by the standard error of the deer coefficient in Equation (6) yields a t-value of 1.29, which falls far short of being significant at the five percent probability level. Therefore, the hypothesis that a ten percent increase in deer numbers would lead to a ten percent increase in consumers' surplus is not rejected.

The same procedure can also be used to estimate a desired coefficient for increased elk numbers which would increase the consumers' surplus by the same percent. Assuming a ten percent increase in consumers' surplus from a ten percent increase in the number of elk harvested would imply from Equation (6) and the same steps outlined for deer that

$$(13) \quad \ln\,(1.10) = 0.09531 \div 309.2\ \hat{\beta}^{*}_{ELK},$$

where 309.2 is the ten percent increase in the number of elk harvested in the first hunting region of Northeast Oregon. The desired elk coefficient can be obtained by dividing 0.09531 by 309.2, giving a value of 0.0003083. The t-test was made to see if the desired elk coefficient was significantly different from the original OLS elk coefficient. Subtracting 0.0003083 from the original elk coefficient (0.0004796) gives a value of 0.0001713. Dividing this value (0.0001713) by the standard error of the elk coefficient in Equation (6) yields a t-value of 1.25 which falls far short of being significant. Therefore, the hypothesis that a ten percent increase in elk numbers would lead to a ten percent increase in consumers' surplus is not rejected.

It should be noted that the data were aggregated into only five hunting regions (two in the Northeast and three in the Central, as shown in the Appendix). These five regions provide only five different levels of elk and deer harvest, not enough observations to estimate very accurately the coefficients for the deer and elk harvest variables. Data from a new survey is needed to obtain more acurate estimates of these coefficients.

VII. SUMMARY AND CONCLUSIONS

It is without doubt that outdoor recreation is important to almost all segments of society. However, the fact that much of the outdoor recreation is provided by public agencies creates an economic problem, specifically that of measuring the value of a recreational resource which does not have a conventional market price. Without a price to guide or direct the allocation of resources, it is more difficult to obtain optimal decisions in allocation of these publicly owned natural resources among alternative uses, including recreation, timber, and domestic livestock production. The absence of a price for the outdoor recreation has been a challenge to a number of economists to develop methods to estimate the economic values accruing to outdoor recreation.

In Oregon, the big game resource has a great impact on the economy of the state. Positive values of this resource are related to recreational use and to income generated which benefit local economies. Negative values of big game include its competition for resources used for timber production and/or livestock grazing.

In order to better assess the value of the big game resource, a mail survey of Oregon big game hunters was conducted during the fall of 1968. In the first phase of the survey, about 3,000 questionnaires were mailed to a random sample of licensed hunters before the general deer season. This first questionnaire was concerned with the investment by the hunter and his family in hunting and associated equipment. In the second phase of the survey, big game hunting trip records were mailed to the hunters. The hunters were asked to record all their hunting trip expenses in these hunting trip records. The data used in this study was obtained from the second questionnaire, the hunting trip record.

The travel cost method was used to measure the willingness to pay from the actual behavior of participants because it has stood the test of time and it is generally recommended for use whenever possible (Dwyer, Kelly, and Bowes, 1977). Several algebric forms of the travel cost based demand equations were estimated for the Northeast and the central regions of Oregon.

The Bowes-Loomis suggested generalized least squares procedure was used to estimate the linear demand functions. The dependent variable, hunting trips, was expessed on a per capita basis, and the distance coefficient was constrained to be equal to 0.35 times the travel cost coefficient to account for the cost of time.

The concept of consumer surplus was used to estimate the net economic value of Oregon big game. Net economic value for the Northeast and the central regions of Oregon in 1968 was approximately $14.3 million, based upon the exponential demand function. Net economic value for the same two regions was approximately $11 million, based upon the linear demand function. An attempt was made to predict the changes in consumers' surplus from changes in the number of deer and elk harvested.

Note that the regression models implied that a ten percent increase in harvest would increase the consumers' surplus of hunters by more than ten percent. However, the hypothesis that a ten percent increase in harvest would increase consumers' surplus by exactly ten percent was not rejected by a statistical test. Therefore, a good deal more research is needed to determine the value of marginal changes in the number of elk and deer harvested.

Limitations and Recommendations for Further Research

At this point it should be noted that results obtained by this thesis will not solve all of the problems associated with the big game resource. For example, willingness to pay by the hunters is not directly related to the economic activity generated by hunting. It is true that the economic impacts can be estimated from some of the same data used to estimate willingness to pay. However, the 1968 data did not give any information about where expenditures were made. Consequently, a new survey of hunters is needed to indicate the counties in which the expenditures are made. Such data could then be used to show where the economic activity generated from hunting occurs. At this time it is thought that only a small percentage of total hunter expenditures are made in the Northeast Oregon counties where most of the big game hunting is done.

More research is also needed to determine the value of marginal changes in the number of elk and deer harvested. It should be noted that for the demand models estimated in this thesis, it is necessary to assume that the estimated coefficients apply uniformly to all hunting regions, as mentioned by Freeman, p. 213. In other words, except for travel cost, distance, deer and elk harvest, all hunting regions are assumed to be essentially identical and perfect substitutes for one another. Further research with more sophisticated models would be necessary to test the suitability of the models used in this thesis. At any rate, if improved estimates of the marginal values of additional deer and elk harvest could be obtained, then these values could be incorporated into simulation or linear programming models to better optimize the production of deer and elk versus timber production and domestic livestock.

Finally, it should be noted that the basic data used for estimating the net economic value of big game hunting are now nearly 13 years old. Changes in transportation costs, big game herd composition and location, and hunting patterns could change the estimates of net economic value. Therefore, a new survey of big game hunters is needed.

BIBLIOGRAPHY

Bowes, M.D. and J.B. Loomis. "A Note on the Use of Travel Cost Models with Unequal Zonal Populations", Land Economics, Vol.56 November 1980.

Brown, W.G., D.M. Larson, R.S. Johnston, and R.J. Wahle. Improved Economic Evaluation of Commercially and Sport-Caught Salmon and Steelhead of the Columbia River. Oregon Agriculture Experiment Station Special Report #463, Corallis, August 1976.

Brown, W.G., F.H. Nawas, and J.B. Stevens. The Oregon Big Game Resource: An Economic Evaluation. Oregon Agriculture Experiment Station Special Report #379, Corvallis, March 1973.

Brown, W.G., A. Singh, and E.M. Castle. An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fishery. Oregon Agriculture Experiment Station Technical Bulletin 78, Corvallis, September 1964.

Brown, W.G., C.N. Sorhus, B. Chou-Yon, and J.A. Richards. A Note of Caution on the Individual Observations for Estimating Outdoor Recreational Demand Functions. Department of Agricultural and Resource Economics, Oregon State University. Unpublished paper. June 1980.

Cesario, F.J. and J.S. Knetsch. "Time Bias in Recreation Benefit Estimates," Water Resources Research, 1970, pp. 700-704.

Clawson, Marion. Methods for Measuring the Demand for and Value of Outdoor Recreation. Reprint No. 10, Resources for the Future, Inc., Washington, D.C., 1959.

Cocheba, D.J. and W.A. Langford. "Wildlife Valuation: The Collective Good Aspect of Hunting," Land Economics, 54:4, 1978, pp. 490-502.

Davis, R.K. "The Value of Big Game Hunting in a Private Forest." Transactions of the Twenty-Ninth North American Wildlife and Natural Resources Conference. March 9-11, 1958. Published by Wildlife Management Institute, Wire Building, Washington, D.C. 1964, pp. 393-403.

Davis, W.C. Values of Hunting and Fishing in Arizona. Bureau of Business. Pub Res. University of Arizona, Special Studies No. 21.

Dwyer, J.F., J.R. Kelly, and M.D. Bowes. Improved Procedures for Valuation of the Contribution of Recreation to National Economic Development. Water Resource Center Research Report #128, University of Illinois at Urbana, September 1977.

Edwards, J.A., K.C. Gibbs, L.J. Guedry, and H.H. Stoevener. The Demand for Non-Unique Outdoor Recreational Services: Methodological Issues. Oregon Agriculture Experiment Station Technical Bulletin #133, Corvallis, May 1976.

Francy, G. Talk delivered at Oregon State University Extension Service Seminar on Elk Management, LaGrande, Oregon, April 1980.

Freeman, A.M. The Benefits of Environmental Improvement. John Hopkins University Press, Baltimore, 1979.

Hotelling, H. Letter to the Director of the National Park Service, reproduced by the Land and Recreational Planning Division, National Park Service, The Economics of Public Recreation (The "Prewit Report") Washington, D.C. 1949.

King, R.T. The Future of Wildlife in Forest Land Use. Transactions of the North American Wildlife and Natural Resources Conference, Vol. 12, pp. 454-467.

Knetsch, J.L. "Outdoor Recreation Demands and Benefits." Land Economics, November 1963, pp. 387-396.

Martin, W.E., R.L. Gum, and A. Smith. The Demand for and Value of Hunting, Fishing, and General Rural Outdoor Recreation in Arizona. Agricultural Experimesnt Station, University of Arizona, Tuscon, June 1974.

McConnell, K.E. and I. Strand. "Measuring the Cost of Time in Recreation Demand Analysis: An Application to Sportsfishing." American Journal of Agricultural Economics, Vol. 63, 1981, pp. 153-156.

Oregon Atlas. Land Ownership. University of Oregon Books, 1976, p. 20.

U.S. Bureau of Census, Census of Population. Characteristics of the Population, Vol. 1, U.S. Government Printing Office, Washington, D.C., 1970.

Wetzel, James N. "Estimating the Benefits fo Recreation Under Conditions of Congestion," Journal of Environmental Economics and Management. Vol. 6, No. 3, 1979, pp. 239-246.

APPENDIX

The following basic data were used to estimate the demand functions for Oregon big game hunting.

Region	HNTR	DIST	TC	PVPT	ELK	DEFF	POPN
Region 1	.0574	174	076.75	0.7544	3092	22960	039619
	.4873	000	029.96	0.7544	3092	22960	034664
	.0467	065	075.65	0.7544	3092	22960	030442
	.0155	202	080.08	0.7544	3092	22960	025011
	.0645	174	086.25	0.7544	3092	22960	039619
	.0503	174	062.57	0.7544	3092	22960	039619
	.0503	174	061.37	0.7544	3092	22960	039619
	.0431	174	088.51	0.7544	3092	22960	039619
	.0395	174	097.95	0.7544	3092	22960	039619
	.0646	174	052.72	0.7544	3092	22960	039619
	.0431	174	146.05	0.7544	3092	22960	039619
	.0575	174	067.91	0.7544	3092	22960	039619
	.0574	174	047.48	0.7544	3092	22960	039619
	.0646	174	103.21	0.7544	3092	22960	039619
	.3185	000	033.75	0.7544	3092	22960	004465
	.0189	178	079.65	0.7544	3092	22960	075655
	.0188	178	093.47	0.7544	3092	22960	075655
	.0110	170	044.80	0.7544	3092	22960	071194
	.0185	174	079.80	0.7544	3092	22960	107791
	.1023	202	041.75	0.7544	3092	22960	025011
	.0212	174	069.44	0.7544	3092	22960	107701
	.0104	277	154.94	0.7544	3092	22960	192022
	.0179	196	197.96	0.7544	3092	22960	079531
	.0885	029	041.41	0.7544	3092	22960	032119
	.0360	156	052.30	0.7544	3092	22960	055363
	.0360	156	087.23	0.7544	3092	22960	055353
	.0348	234	067.86	0.7544	3092	22960	057263
	.0360	156	109.91	0.7544	3092	22960	055363
	.0795	077	65.210	0.7544	3092	22960	021735
	.4269	000	021.00	0.7544	3092	22960	004669
	.0424	204	070.35	0.7544	3092	22960	040213
	.0252	194	083.76	0.7544	3092	22960	078960
	.6547	000	022.67	0.7544	3092	22960	006418
	.0862	174	046.58	0.7544	3092	22960	039619
	1.3844	000	035.14	0.7544	3092	22960	001843
	.0252	194	092.93	0.7544	3092	22960	078960
	.0983	091	034.44	0.7544	3092	22960	030133
	.1174	000	026.28	0.7544	3092	22960	019377
	.3988	000	029.74	0.7544	3092	22960	006418
	.6204	000	027.59	0.7544	3092	22960	006418
	.4432	000	027.70	0.7544	3092	22960	006418
	.3102	000	055.32	0.7544	3092	22960	006419
	.5318	000	031.95	0.7544	3092	22960	006418
	.2659	000	055.55	0.7544	3092	22960	006418
	.0287	174	142.11	0.7544	3092	22960	039619
	.0503	174	079.85	0.7544	3092	22960	039619
Region 2	.0215	280	119.33	0.4667	2763	22300	078960
	.0151	348	114.86	0.4667	2763	22300	075297
	.0241	394	151.86	0.4667	2763	22300	047267
	.0241	394	099.99	0.4667	2763	22300	047267
	.0320	280	067.20	0.4667	2763	22300	053363
	.0320	280	170.45	0.4667	2763	22300	053363
	.0267	280	108.57	0.4667	2763	22300	053363
	.6100	000	033.31	0.4667	2763	22300	003730
	.6100	000	025.69	0.4667	2763	22300	003730
	1.5250	000	031.08	0.4667	2763	22300	003730
	.7625	000	032.88	0.4667	2763	22300	003730
	1.1836	000	029.67	0.4667	2763	22300	003124
	.6373	000	045.07	0.4667	2763	22300	003124
	.1725	000	084.68	0.4667	2763	22300	021433
	.1725	000	097.78	0.4667	2763	22300	021433
	.1194	000	081.17	0.4667	2763	22300	021433
	.0571	074	080.43	0.4667	2763	22300	024923
	.1289	027	079.58	0.4667	2763	22300	015466
	.0202	299	116.13	0.4667	2763	22300	056364
	.0081	400	138.06	0.4667	2763	22300	141264
	.0455	171	093.83	0.4667	2763	22300	043629
	.0173	416	071.66	0.4667	2763	22300	114880
	.0231	260	097.84	0.4667	2763	22300	110934
	.0179	260	116.07	0.4667	2763	22300	110934
	.0128	260	105.57	0.4667	2763	22300	110934
	.0158	295	256.17	0.4667	2763	22300	108076
	.0283	280	105.75	0.4667	2763	22300	078960
	.0124	290	080.40	0.4667	2763	22300	115145
	.0132	291	102.15	0.4667	2763	22300	107701
	.0158	291	093.35	0.4667	2763	22300	107701
	.0154	260	126.83	0.4667	2763	22300	110934
	.0179	260	120.93	0.4667	2763	22300	110934

Region	HNTR	DIST	TC	PVRT	ELK	DEER	POPN
Region 3	0.0082	200	065.06	0.3530	02	18460	277334
	0.0302	210	107.70	0.3530	02	18460	056515
	0.1531	200	057.93	0.3530	02	18460	013005
	0.0061	200	108.49	0.3530	02	18460	324008
	0.0082	200	077.09	0.3530	02	18460	277334
	0.0557	070	052.68	0.3530	02	18460	035746
	0.4265	000	021.81	0.3530	02	18460	010004
	0.2559	000	046.79	0.3530	02	18460	010004
	0.1990	000	023.39	0.3530	02	18460	010004
	0.3412	000	020.40	0.3530	02	18460	010004
	0.4265	000	027.67	0.3530	02	18460	010004
	0.0396	090	064.79	0.3530	02	18460	043090
	0.0660	090	041.19	0.3530	02	18460	043080
	0.0660	090	079.06	0.3530	02	18460	043087
	0.0462	090	047.86	0.3530	02	18460	043090
	0.0462	090	039.61	0.3530	02	18460	043080
	0.0542	040	029.02	0.3530	02	18460	031511
	0.1083	040	035.87	0.3530	02	18460	031511
	0.0934	050	024.17	0.3530	02	18460	015221
	0.1682	050	025.90	0.3530	02	18460	015221
	0.0317	090	062.51	0.3530	02	18460	071743
	0.0812	040	043.49	0.3530	02	18460	031511
Region 4	0.0113	060	030.33	0.6829	41	5100	277334
	0.0093	140	022.03	0.6829	41	5100	136499
	0.0040	088	034.53	0.6829	41	5100	352481
	0.0062	060	031.04	0.6829	41	5100	277334
	0.1590	000	028.79	0.6829	41	5100	023254
	0.1529	000	023.56	0.6829	41	5100	020454
Region 5	0.0134	243	043.37	0.4075	55	14310	084749
	0.0132	115	040.53	0.4075	55	14310	172563
	0.3621	000	025.56	0.4075	55	14310	010210
	0.0157	114	033.81	0.4075	55	14310	144554
	0.0356	085	026.52	0.4075	55	14310	047943
	0.0137	100	044.40	0.4075	55	14310	103502
	0.1671	000	025.85	0.4075	55	14310	010210
	0.0132	123	058.79	0.4075	55	14310	194898
	0.0132	115	073.67	0.4075	55	14310	172563
	0.0357	080	074.29	0.4075	55	14310	071800
	0.1950	000	029.66	0.4075	55	14310	010210
	0.2849	000	021.75	0.4075	55	14310	009985
	0.0188	093	058.53	0.4075	55	14310	075655
	0.0059	150	053.81	0.4075	55	14310	339103
	0.0301	093	068.03	0.4075	55	14310	075655
	0.0205	100	056.59	0.4075	55	14310	083044
	0.0239	080	046.15	0.4075	55	14310	071800
	0.0199	080	021.42	0.4075	55	14310	071800
	0.0115	115	054.29	0.4075	55	14310	172563
	0.0274	100	060.29	0.4075	55	14310	010210

HNTR: Hunting trips per capita.

DIST: Estimated one-way distance from hunters' residence to edge of hunting region.

TC: Average cost incurred per hunting teip (costs include food, transportation, ammunition, lodging, and tags).

PRVT: Proportion of private land to public land.

ELK: Number of elk harvested in 1968.

DEER: Number of deer harvested in 1968.

POPN: The population of each distance zone.

REGION 1: Refers to game management units of Wenaha, Sled Springs, Chesnimnus, Imnaha, Snake River, Lookout Mountain, Keating, Catherine Creek, Baker, and Minam of the Northeast region.

REGION 2: Refers to game management units of Columbia Basin, Heppner, Wheeler, Northside, Desolation, Starkey, Umatilla, Ukiah, Murderers Creek, and Walla Walla of the Northeast region.

REGION 3: Refers to game management units of Interstate, Silver Lake, Keno, Klamath, Sprague, and Fort Rock of the Central region.

REGION 4: Refers to game management units of Hood River, Wasco, Sherman, and Maupin of the Central region.

REGION 5: Refers to game management units of Grizzly, Metolius, Ochoco, Maury, Paulina, and Deschutes of the Central region.