Towards estimating the optimum combination of cattle and elk on the Apache-Sitgreaves National Forest of Arizona

TOWARDS ESTIMATING THE OPTIMUM COMBINATION OF CATTLE AND ELK ON THE APACHE-SITGREAVES NATIONAL FOREST OF ARIZONA

by

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THE UNIVERSITY OF ARIZONA

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STATEMENT BY AUTHOR

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SIGNED: Mary Ann Helfrich

APPROVAL BY THESIS DIRECTOR

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Professor of Agricultural Economics

15 July 81
Date

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ABSTRACT

The problems of comparing market and non-market products of a given resource base, and of discovering an optimal level of allocation between such competing resource uses, are the focus of this study. An original case study which compares cattle and elk production in the Apache-Sitgreaves National Forest of Arizona facilitates the research. Elk production is valued using methods of non-market valuation suggested by the U.S. Water Resources Council. The three methods of valuation suggested are themselves reviewed for their applicability. A net social benefit of elk production is found and compared to the net social value of cattle production. Production possibilities frontiers between cattle and elk in the forest are developed. The production possibilities frontiers are related to the net social values to estimate the range of production which approaches an optimum net social value to society.

CHAPTER 1

INTRODUCTION

Justification

As the population of the planet increases, scarcity is a growing problem. Because the alternative uses for any natural resource compound with increased scarcity, proper planning is essential to ensure the greatest social benefit to the population.

Too often the dollar values of goods sold in the market play the dominant role in resource usage. Market values are good measures of how society values many items; and, they have their place in planning. However, many activities and uses of our natural resources are not valued in the market and thus do not carry a dollar price tag. This is not to say that they have no value. On the contrary, many non-market uses of the great outdoors, particularly activities related to outdoor recreation are valued highly by society.

The point is that the values of non-market uses of a resource base must be incorporated into the planning of resource use. To do so, values comparable to values found in the market place must be derived for non-market activities. Several analytical techniques for non-market valuation exist. All of the techniques are, however, still subject to improvement.

One purpose of this paper is to contribute to the effort to improve the methods of non-market valuation. A second purpose is to study the methodology involved in comparing non-market goods to market goods as an aid in the planning for use of our natural resources. An original case study will facilitate the research.

Problem Definition and Tactics

The multiple use concept of land management has been used by the U.S. Forest Service since the early part of the century. The U.S. Congress made the multiple use concept law with the passage of the Federal Land Policy and Management Act of 1976. In this Act the Congress specifically states that "it is the policy of the United States that . . . management be on the basis of multiple use and sustained yield . . . ," (PL 94-579).

Presently the Apache-Sitgreaves National Forest is a multiple use resource. Approximately 27,000 cattle and 13,000 domestic sheep graze on land leased from the National Forest. Apache-Sitgreaves also supports a number of wildlife species which compete with domestic livestock for food. Lumbering and mining are two other productive uses of the forest. The forest, therefore, has value as a resource base for production of livestock and other market goods; as a recreational resource for hunting wild game, hiking, camping and fishing; and value simply for its aesthetic appeal.

Of main concern in this study is the competition between cattle and elk. The National Forest Service is considering increasing cattle grazing allotments. Approximately 92.7 percent ofthe Apache-Sitgreaves is already alloted for cattle grazing; domestic sheep graze in 5 percent, leaving 2 percent unallocated. An increase in cattle grazing allotments will, therefore, be administered in the form of increased density of cattle on existing ranches. Since cattle and elk compete directly for available forage and space, it is hypothesized that the elk herd will diminish as the number of cattle allotments are increased.

This paper explores the multiple use concept of land management through a case study involving the value of the Apache-Sitgreaves National Forest when used in each of two alternatives, the production of domestic cattle or the production of elk. Prescription is made for a combination of use in which both are produced for the maximum net social benefit.

The specific objectives of this paper and an outline of the procedures used to accomplish these objectives follows.

Objectives

(1) Review and compare valuation techniques.

(2) Estimate the value of the Apache-Sitgreaves National Forest as a resource base used to graze elk.

(3) Estimate the value of the Apache-Sitgreaves National Forest as a resource base used in cattle production.

(4) Estimate a production possibilities frontier between cattle and elk given the physical limitations of the Apache-Sitgreaves National Forest.

(5) Estimate the optimum combination of elk and cattle to be grazed in the national forest based on the production possibilities frontier and respective value estimates.

Procedure for Objective (1). The easiest way to compare the values of goods and services is with market prices. However, not all goods and services are valued in the market. Alternative means of valuation are necessary when one or all of the items meant for comparison are not valued in the market. The measure of product value known as consumer's surplus is used to compare the values of elk production and cattle production. The theory of consumers' surplus is reviewed.

The consumers' surplus of a market good can be found directly using known prices and quantities. The valuation process becomes more difficult for non-market valued items such as recreation. Three methods of valuation of water related recreation are suggested by the U.S. Water Resources Council in their Principles and Standards for planning of water resources (U.S. Water Resources Council, 1979). They are: the travel cost method, the contingent valuation method and the unit-day value approach.

The three methods discussed in the Principles and Standards first are reviewed conceptually. Following the empirical analysis, the three methods are compared as to their applicability to valuation of a resource base when used to graze elk.

Procedure for Objective (2). Elk hunting as a recreational experience is an activity which when valued will approximate the value of the land base for elk production. As inferred in objective (1), all three methods of recreation valuation suggested in the Principles and Standards are used to estimate the value of the elk hunting experience.

Data utilized in this section of analysis were obtained, at least partially, from a mail survey. The survey was sent to a representative sample of elk hunters, all of whom purchased a permit in 1979 allowing them to hunt in the Apache-Sitgreaves National Forest area.

Procedure for Objective (3). Both price and quantity information is available for cattle production. Thus the value of cattle production is more readily attainable than for elk production because a demand curve is easier to generate. Two points on the demand curve are derived. The first is the current price and quantity; the second is the price and quantity of cattle demanded given a 100 percent reduction in the Apache-Sitgreaves cattle crop. The change in consumers' surplus, given that reduction, is the value of the Apache-Sitgreaves cattle crop to the consumers in the national market. The value to the people of Arizona only is a small proportion of the national value.

Because cattle are sold in the market, there are benefits to both consumers and producers. The sum of the benefits to these two groups of beneficiaries is the total value of cattle production. Producers' surplus, the compliment of consumers' surplus, is derived and added to the consumers' surplus to arrive at a total value of cattle production which is comparable to the value of elk production.

Procedure for Objective (4). The slope and shape of the product transformation curve between cattle and elk is developed from the biological and habitual characteristics of the animals. The position of the curve is based on the physical limitations of the resource base. Once positioned the curve is known as the production possibilities frontier.

A great deal of the information used in this portion of the analysis is obtained from the National Forest Service and the Arizona Department of Game and Fish.

Procedure for Objective (5). The relative values of the resource base when used for cattle or elk production (the estimated way in which society values each usage) are the basis of a iso-net-benefit line. The tangency of this iso-net-benefit line with the production possibilities frontier is the point of optimum multiple usage when the goal is to maximize total net social benefits.

CHAPTER 2

THEORETICAL FRAMEWORK

Consumers' Surplus

Consumers' surplus is used to measure the value of the resource base when used to graze cattle and its value when used to produce elk. It is a means to compare the values of the two activities since elk have no market price.

Consumers' benefit is the total value of a given product. In Figure 2.1 the shaded area is the consumers' benefit; the area under the demand curve up to the quantity purchased. It is equal to the amount paid (P_o X Q_o0) plus the extra benefit of being able to buy the product at a lower price than many were willing to pay.

The area of "extra" benefit is known as the consumers' surplus. It is the area under the demand curve above the price which is paid, shown as the shaded area in Figure 2.2. Except for the case of a perfectly discriminating monopolist, there will always be people who would have paid a higher price for a product than that which was paid. The discriminating monopolist would charge every person exactly what they are willing to pay. In that case there would be no consumers' surplus.

Consumer's surplus is not a new idea. It was first discussed in 1844 by Depuit. He defined "surplus" (consumer's surplus as we know it today) as "the difference between the sacrifice which the purchaser would be willing to make in order to get it and the purchase price he has to

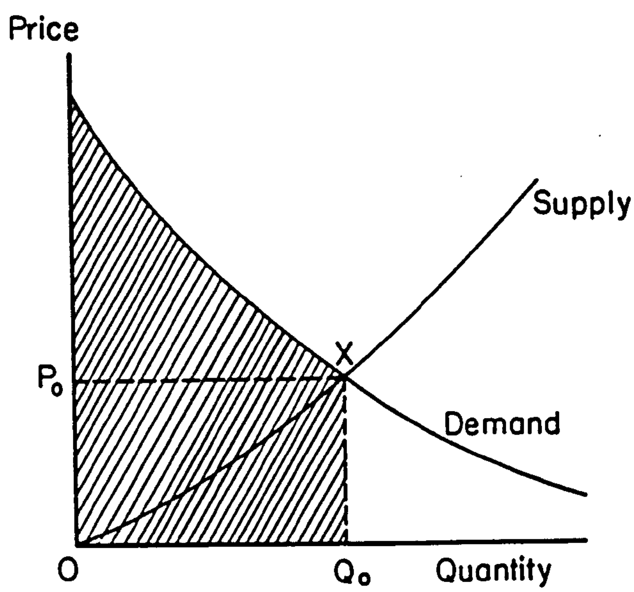

Figure 2.1. Total consumers' benefit (theoretical).

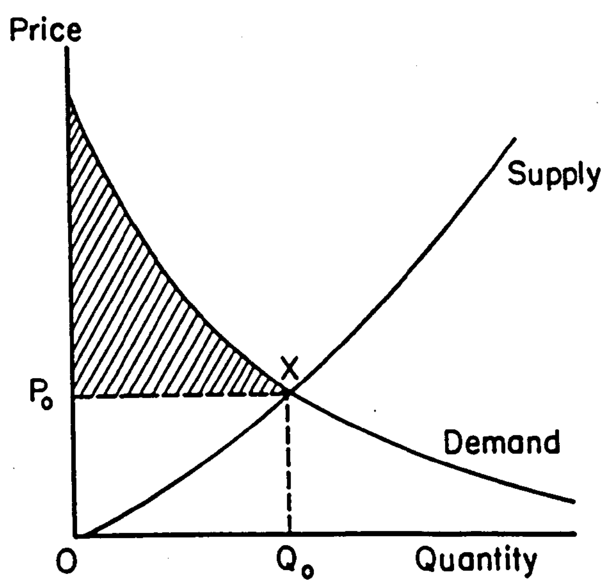

Figure 2.2. Consumers' surplus (theoretical).

pay in exchange," (Currie, Murphy and Schmitz, 1971, p.742). However, the concept of consumer's surplus is most often accredited to Marshall (1936). Both economists spoke, in essence, of the integral below the demand curve above the price which was paid. The difference is that Depuit's surplus was strictly a monetary measure, while Marshall defined consumer's surplus in terms of a consumer's utility (Currie et al., 1971). Marshall also extended his analysis to the aggregate concept of consumers' surplus. Study was then possible of the change in the welfare position of groups.

In 1943 Hicks further detailed the concept of consumer's surplus by explaining that there was not simply one measure of it but four. Those four measures are equivalent surplus (ES), equivalent variation (EV), compensating surplus (CS) and compensating variation (CV).

These are measures of change in a consumer's welfare given a change in the consumer's opportunity set due to a change in policy or price. They all account an amount of compensation which must be paid or received from a consumer under varying circumstances.

ES = The amount of compensation necessary to bring the consumer to his subsequent welfare level in the absence of a price change if he is not permitted to make changes in his bundle of goods.

EV = The amount of compensation necessary to bring the consumer to his subsequent welfare level in the absence of a price change if he is permitted to make changes in his bundle.

CS = The amount of compensation necessary to leave the consumer in his original welfare state after a price change if he is not permitted to make changes in his bundle of goods.

CV = The amount of compensation necessary to leave the consumer in his original welfare state after a price change if he is permitted to make changes in his bundle.

The difference between equivalent and compensating measures is a matter of the assignment of rights. Equivalent measures assume the consumer has a right to his subsequent welfare position or utility level. Compensating measures assume the consumer has a right to his original welfare position or utility level.

ES, EV, CS and CV like simple consumer's surplus were designed to measure the change in the welfare of the individual in changing circumstances. However, the surplus or variation of a population can be approximated with aggregating techniques if the researcher assumes the indifference maps of individual consumers are not extremely different.

For normal goods ES < EV < simple Marshallian consumer's surplus < CV < CS for a price increase. ES > EV > simple Marshallian consumer's surplus > CV > CS for a price decrease. All four measures and the Marshallian consumer's surplus are equal when the income effect of a price change or the welfare effect of a change in the opportunity set is zero. Willig (1976) has shown if the income effect is small, that is if the income elasticity of demand is between ± 1.0, and the proportion of a consumer's total income spent on the good is small; then CV, EV and Marshallian consumer's surplus are insignificantly different.

Values of Elk Hunting and Cattle Production

Consumers' Values

The value of elk hunting is estimated as the aggregate willingness of consumers to pay for the elk hunting experience as it exists today or do completely without. Conceptually one is searching for the income compensated demand curve which would yield the compensating variation. As for the value of cattle, the compensating variation resulting from a 100 percent decrease in cattle raised in the Apache-Sitgreaves National Forest is the measure sought.

Martin, Tinney and Gum (1978) tested Willig's conclusions concerning compensating variation and Marshallian consumers' surplus in a study of the values of cattle ranching and all hunting activities in Arizona. Their analysis substantiated Willig's position with respect to those two products. Therefore, the values of elk hunting and cattle ranching in this study are approximated using simple Marshallian consumers' surplus.

Figures 2.3 and 2.4 illustrate, conceptually, the changes in consumers' values for elk and cattle production as valued in this study. In Figure 2.3 the demand curve depicts demand by elk hunters in Arizona for elk permits to hunt in the Apache-Sitgreaves Forest area. P_1 is the current price of a permit and Q_1 permits are requested. Since there is no supply function, the entire area OP_2aQ_1 is the measure of the net social benefit. This area is composed of the amount of fees that would be paid by the hunters (OP_1aQ_1) plus the consumers surplus of the hunters (P_1P_2a). Because the price of a permit is set

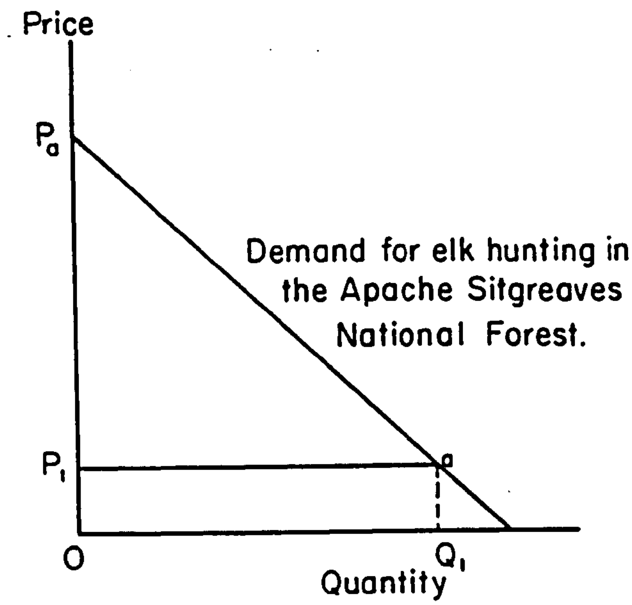

Figure 2.3. The value of elk hunting in the Apache-Sitgreaves National Forest area (hypothetical).

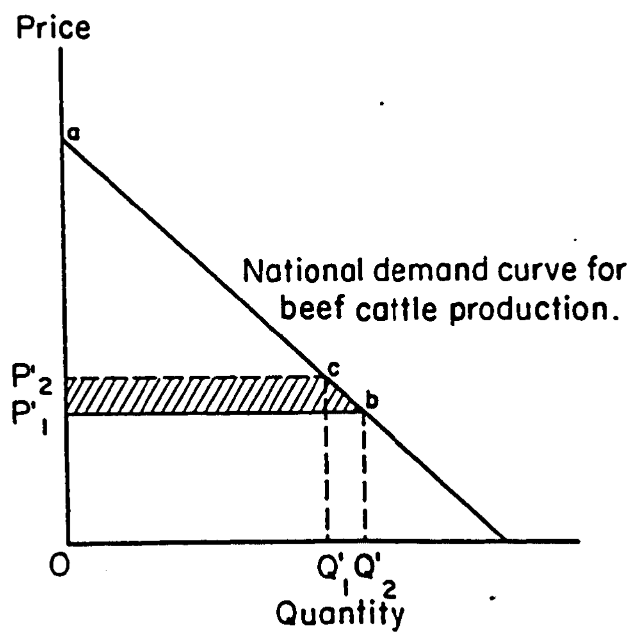

Figure 2.4. The change in consumers' surplus for beef cattle production in the Apache-Sitgreaves National Forest (hypothetical).

by administrative fiat rather than the interaction of supply and demand, area OP_1aQ_1 is only a transfer payment and is included in the net social benefit of the hunt.

The demand for beef production is nationwide. Any change in production will effect the national market. Therefore; the demand curve shown depicts the national demand for beef. Q_1' is the current level of consumption at a price P_1'. With a decrease in production will come an increase in price. Q_2' is the predicted new level of consumption at the higher price of P_2'. At the original price and quantity the consumers' surplus is equal to area abP_1'. The area of consumers' surplus at the predicted new level of consumption is acP_2'. The change in consumers' surplus is area $P_2'cbP_1'$. This area is the value of the Apache-Sitgreaves cattle crop to the national market. The value is converted to a per capita basis, then multiplied times the population of Arizona to obtain the value to Arizonans of the cattle crop. The value is then comparable to the value of the resource base to Arizonans for elk production.

Producers' Values

Consumers' surplus is the relevant concept for valuing outdoor recreation, because consumers are the only group upon which benefits are bestowed. However, where market goods are concerned consumers are not the only beneficiaries; producers also benefit. The value of a commodity to producers is known as the producers' surplus. Total net benefit to society of a market good is a sum of the consumers' and producers' surplus.

Marshall (1930) is credited with the development of producers' surplus. The concept is described in his book Principles of Economics first published in 1890. Producers' surplus is the extra benefit above costs producers receive from being able to sell their product at a given price. Like consumers' surplus it was first designed to measure the benefits to an individual producer.

See Figure 2.5. The producer received P_oXQ_o0 for the product he is offering. Since the supply curve is the marginal cost curve above the average variable cost curve, it costs the producer area C to produce in the short run. Area B is the producer's surplus, the extra benefit received. This benefit is the return to (value of) the fixed resources which for cattle production basically is the land and forage resource. By assuming that the supply and demand curves shown are the aggregate curves for the market, area B is the producers' surplus.

If Figure 2.5 depicted only the supply and demand for beef from the Apache-Sitgraves National Forest in Arizona, then area B (the producers' surplus) would be entirely lost when the production was eliminated. On a larger scale there are producers who loose and producers who gain from a cut back in production. If you are a producer whose production is cut back or eliminated, you loose. If you produce outside the area of production cut back, you gain, at least in the short run, from a price increase. Eventually, if there is a shortage created by the production cut back, the slack will be usurped by outside producers; and, the price will fall to its equilibrium level.

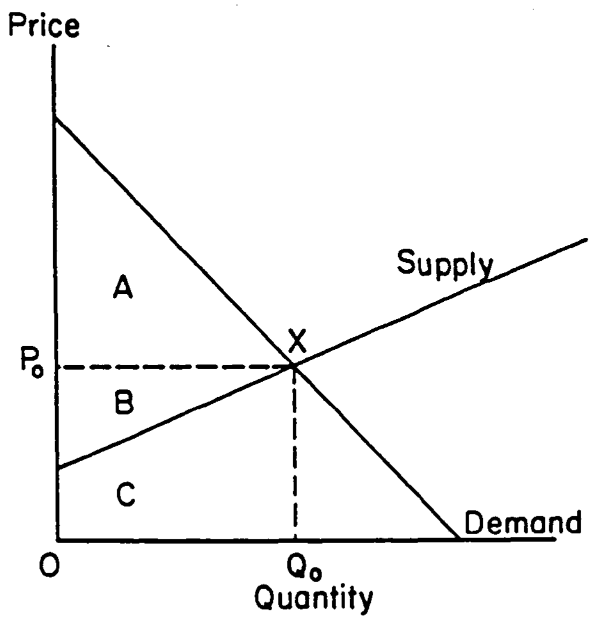

Figure 2.5. Producers' surplus of cattle production on the small scale (conceptual).

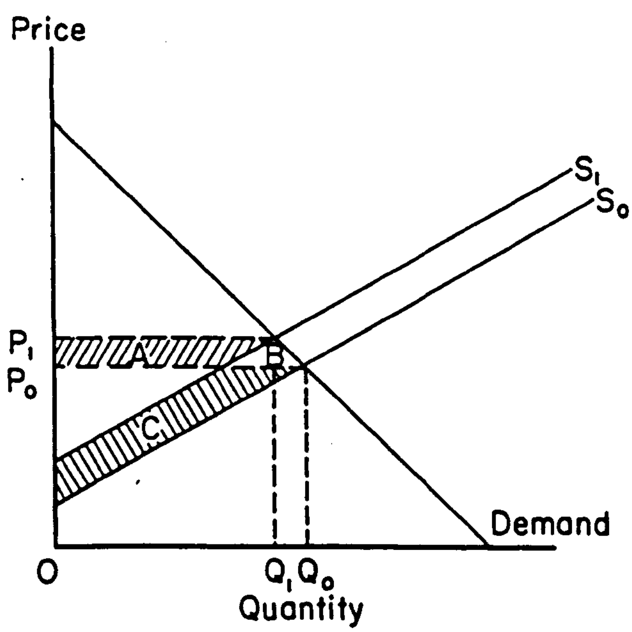

Figure 2.6. Change in producers' surplus on the large scale (conceptual).

Figure 2.6 illustrates conceptually the change in producers' surplus on the large scale. Assume that Figure 2.6 depicts the demand and supply of beef in the U.S. If the cattle crop in the Apache-Sitgreaves Forest is eliminated, the supply of beef will shift from S_o and S_1 boosting the price from P_o to P_1 and lowering the quantity demanded from Q_o to Q_1. Producers loose area C and gain area A the difference of which is the change in producers' surplus.

Area A + B is the change in consumers' surplus as explained in the previous chapter. (Assuming a constant marketing margin, the change from P_o to P_1 will be the same whether 2.6 is a farm level or retail diagram.) The loss to consumers adjusted for the gain to producers, plus the loss to producers ((A+B) - A) + (C) is the total net loss to society resulting from an elimination of the Apache-Sitgreaves cattle crop. It is the value of the crop to society.

Estimating Recreation Demand

To estimate consumers' surplus one must first estimate demand. For market goods demand estimation is not usually a difficult task because both price and quantity information are available; and, the demand curve may be directly derived using linear regression methods. The route to a demand curve for a recreation site or activity is more indirect because only quantity data are available. However, consumers do place different values on different recreation quantities. Several techniques have been developed to measure these values.

Three alternative techniques are used and compared in this study. The three techniques are those specified in the Principles and

Standards for water resources planning (U.S. Water Resources Council, 1979). They are the travel cost method (TCM), the contingent valuation method (CVM) or willingness to pay (WTP) approach, and the unit day value (UDV) approach.

The Unit Day Value Approach

The unit day value (UDV) approach is a means of approximating the average WTP for a day's recreation without asking a sample of people directly. It was designed as a temporary means of assigning value to the recreation experience while recreation methodology was being further developed. The Water Resources Council specifies that the analyst should use the UDV approach only if the project cannot be analyzed under either the travel cost method or the willingness to pay approach. Since it is one purpose of this study to compare the different means of analyzing non-market price recreation values suggested by the Principle and Standards, the UDV approach is included in this analysis.

UDV relies on a point system and a set of unit-day values developed by a group of experts. A single unit-day value is developed for each recreation day depending on the category of recreation.

The categories are "general" and "specialized" recreation. Activities falling in the category of general recreation are associated with "intensive development of access and facilities as compared to the specialized recreation class," (P & S, p. 30233). "General" activities commonly associated with water projects include swimming, picnicking, boating and most warm water fishing. In 1979 values assigned to this category range from $1.07 to $3.22 per unit-day.

The values of activities in the category of specialized recreation may be lowered if not actually eliminated with intensive development of an area, the same type of development which enhances activites in the general category. Specialized recreation activities at the upper end of the value range include big game hunting, wilderness pack trips, inland marine fishing for salmon and steelhead, white water boating and canoeing, and long range boat cruises in areas of outstanding scenic beauty. At the lower end of the value range are upland bird hunting and specialized nature photography. Values for this category range from $4.29 to $12.87 per unit day.

The Principles and Standards suggest that values for general and specialized recreation can be adjusted to "reflect additional quality considerations expected to prevail at various project sites . . .," (Water Resources Council, p. 30 and 34). Any adjustments must be accompanied by a full explanation.

Tables illustrating the point system are 4.1 and 4.2 in Chapter 4. Discussion of exactly how the UDV approach was utilized in this study is included in that chapter.

The major criticism of this method is that it is not based on any theoretical construct. The results do not depict a demand curve.

The Contingent Valuation or Willingness to Pay Method Approach

The contingent valuation method (CVM), also known as the willingness to pay (WTP) approach, is designed to find estimates of changes in national economic development benefits due to changes in recreational opportunities or quantities demanded. In utilizing the WTP approach, the researcher asks people directly what they would be willing to pay for varying amounts of recreation. This questioning can be accomplished by several techniques. The Principles and Standards call these techniques, generally, the iterative bidding formats and the non-iterative bidding formats. Iterative bidding formats are most readily accomplished by personal interview. Non-iterative formats are usually followed in mail surveys. By assuming that every person willing to pay $2 is also willing to pay less than $2, the number of respondents willing to pay each amount can be put on a cumulative scale. This cumulative function is the demand curve for the recreational experience.

A directly derived demand curve is a distinct advantage of the WTP method of recreation valuation. There are, however, some inherent biases to be considered when using the WTP approach. People may react differently to questions depending on what they feel is the purpose of the survey. For instance, if interviewees feel the outcome of the survey will be used to adjust permit costs -- they may tend to adjust their true values downward. If interviewees feel results from the survey may increase the quantity and or quality of a recreation site without an increase in any fee, they may tend to adjust their true values upward. It is the responsibility of the researcher to present the purpose of the study and the questions in such a way as to minimize such biases.

The Travel Cost Method

The travel cost method (TCM) of valuing the recreation experience was first suggested by Hotelling in 1949. He proposed that complementary market goods used for a recreational experience could be used to estimate the actual value of the recreational experience. Clawson in 1959 and again in 1966 (Clawson and Knetsch) posits that the use of the recreation site itself is only one part of the total recreational experience from which a consumer gets utility. The consumer also gets utility from anticipation and preparation for the trip, travel to the site, actual on-site experience, travel back from the site and recollection. It is this total experience to which the recreator relates the sum of all his expenditures for the trip. The Clawson-Hotelling TCM has, therefore, developed as a two-step procedure. Step one determines the demand for the total recreation experience. Step two derives a demand for the site (or activity) itself.

In step one the average variable costs from each distance zone are regressed against a quantity variable; visits, days, permits, etc. per capita from several distance zones. That relationship according to Clawson depicts the total demand for the recreational experience.

The demand for the site itself can then be determined by assuming that recreators will react to an increased entrance fee in the same way that they would react to an increase in the cost of their trip. The reaction of recreators to various entrance fees depicts the demand for the site. The total visits made to a site from all zones under the current conditions is one point on the derived demand curve. It is the demand at zero added cost. One may then mathematically find the decreased quantity demanded from each zone at a specified added cost. Summing across the zones yields another point on the derived demand curve, the quantity demanded at the specified added cost. The analyst continues in this manner until he has an entire demand curve derived.

Details on how the TCM was actually used in this study are given in Chapter 4.

CHAPTER 3

THE DATA

Values of Wildlife

Though wildlife certainly has value to hunters, it is also valued in several other ways. The four commonly stated values of wildlife include hunting, observation, option and existence values. The hunting value derives from those who actively pursue and attempt to kill wildlife. There are also persons who actively look for wildlife just to observe it. They place a value on this experience. Further, there are many who have never actually searched for wildlife or gone hunting, but may someday wish to partake in one or both of these activities. A value is placed on that option. There are also persons who know they will never hunt or observe wildlife but, nonetheless, place a value on knowing that it exists. An example of this type of wildlife value is the concern the public can have for an endangered species such as the whale or Bengal tiger, though most will never see one.

The four values of wildlife (hunting, observation, option and existence) are not exclusive of each other. The hunter gains value from observation; an observer may sometimes wish to hunt. And there is a fine line between those who value a wild animal simply for its existence and those who retain an option value.

There is an inherent difficulty in measuring option and existence values. They do not emanate from a defined population set as the value of say, elk hunting, is confined to elk hunters. Also, while observation value is more readily obtainable than option and existence values, it is relatively difficult to measure when compared to finding the value of hunting. Observation value stems from a much more loosely defined population set than hunting value.

Because of the non-exclusive nature of the four values of wildlife, and the difficulty in measurement of three of them, it was decided to measure only the hunting value of elk. It is this value which is used as a surrogate measure of the value of the resource base when used to support an elk herd. The bias of using a value obtained only from elk hunting is that it may underestimate the value of the resource base because those values excluded from the analysis may be of significant magnitude.

The Survey

Contingent valuation methods of valuing hunting, and some travel cost methods, require a survey of participants from which to obtain primary data. The population from which a sample was drawn to survey included all elk hunters who drew elk permits for the 1979-80 elk hunt enabling them to hunt in units selected for study.

Hunt numbers 301, 303 and 351 were permitted to hunt in units 1, 2C, 3A, 3B, 4A, 4B and 27 (Figure 3.2 and 3.7). These units closely coincide with the Apache-Sitgreaves National Forest outlined on the same map. The Forest Service allots cattle grazing permits. Cattle

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF AGRICULTURE
DEPARTMENT OF AGRICULTURAL ECONOMICS
AGRICULTURE BUILDING # 36

June 4, 1980

Dear Elk Hunter:

We in the Department of Agricultural Economics at the University of Arizona are attempting to measure the value of elk hunting to the sportsmen of Arizona. Arizona Game and Fish Department records show that you were drawn for the 1979 elk hunt. Because your hunt number was 351, you may have hunted in an area of particular interest to us where the multiple uses of the land could become in conflict. Therefore it is particularly important that we obtain your elk hunting information on the short, enclosed questionnaire, so as to develop estimates of value for the elk hunting experience.

Your name was drawn in a random sample of all elk hunters holding permits for the 1979 hunt number 351. In order that the results will truly represent the thinking of Arizona hunters, it is important that each questionnaire be completed and returned by the person holding the permit. Please complete and return yours today if possible. A stamped addressed envelope is enclosed. Please complete the relevant parts of the questionnaire even if you did not get to actually go on the hunt.

You may be assured of complete anonymity. Each questionnaire contains an identification number for mailing purposes only. This is so that we may check your name off of the mailing list when your questionnaire is returned. Your name will not be placed on the questionnaire. Furthermore, all results of this study will be published in such a way that answers on any single questionnaire cannot be identified.

The results of this research will be made available to officials and representatives in our state's government and all interested citizens. You may receive a summary of results by writing "copy of results requested" on the back of the return envelope, and printing your name and address below it. Please do not put this information on the questionnaire itself.

We shall be most happy to answer any questions you might have. Please write or call. The telephone number is (602) 626-1794 or 626-1234.

Thank you for your assistance.

Sincerely,

William E. Martin
Professor

M. A. Helfrich
Research Assistant

Figure 3.1. Cover letter from first mailing of survey[a)]

a) Reduced from 8½" X 11"

Figure 3.2. Map of hunting units and study area, as mailed with survey.[a),b)]

a) Source: Arizona Game and Fish Department, 1979.

b) Reduced from 8½" X 11".

VALUE OF ELK SURVEY
DEPARTMENT OF AGRICULTURAL ECONOMICS
UNIVERSITY OF ARIZONA
TUCSON, ARIZONA

CONFIDENTIAL

Please answer as many questions as possible even if you were unable to make your intended hunting trip.

General Elk Hunting Information

1. Did you actually hunt elk in 1979? Yes No (circle one)

2. In which Game and Fish Hunting Unit(s) did you hunt elk in 1979? (refer to map)

   1 2C 3A 3B 4A 4B 27 (circle one or more)

3. How many days did you spend on elk hunting trips in 1979, including travel time? (Count any part of a day as one day.) ______

4. How many scouting trips did you make to the area? ______
   How many days did you spend on each scouting trip, including travel time?
   1st trip ______ days. 2nd trip ______ days. 3rd trip ______ days.

5. Have you hunted elk in the past? Yes No (circle one) If yes, about how many times? In Arizona? ______ In other states? ______

6. How many times have you applied for an elk hunting permit?
   In Arizona? ______ In other states? ______

7. On your 1979 hunting trip did you kill an elk? Yes No (circle one)
   Did anyone else in the group with which you were hunting kill an elk?
   Yes No (circle one)

8. About how many elk did you see? Cows ______ Bulls ______

9. Will you apply for an elk hunting permit the next time you are eligible?
   Yes No Undecided (circle one)

Cost Information

It is necessary to ask the following questions so that we can obtain an accurate estimate of the cost of your elk hunting trip.

1. What was your total gasoline bill for all 1979 elk hunting and scouting trips? If you shared this expense with anyone give only your part of the expenditure. $______

2. What was your total food bill, including restaurant bills and liquor, for all 1979 elk hunting and scouting trips? If you shared this expense give only your part of the bill. $______

3. What was your total lodging bill for all 1979 elk hunting and scouting trips? Give only your share of the bill. $______

OVER

Figure 3.3. Questionnaire from mail survey, page 1[a)]

a) Reduced from 8½" x 11"

4. Check which, if any, of the following items you purchased or rented specifically for your 1979 elk hunting trip and their approximate cost.

Rented	Purchased		Dollars
☐	☐	gun	______
☐	☐	archery equipment	______
☐	☐	ammunition	______
☐	☐	boots	______
☐	☐	clothing	______
☐	☐	sleeping bag	______
☐	☐	tent	______
☐	☐	camping stove	______
☐	☐	tires	______
☐	☐	antifreeze	______
☐	☐	chains	______
☐	☐	other (list)	______

5. Did you purchase an Arizona State hunting license specifically so that you could go elk hunting in 1979? Yes No (circle one)

6. Did you lose any income so that you could make these hunting and scouting trips? Yes No (circle one) If yes, how much? ________

One way in which we can determine how much you value elk hunting is to find out how much you would be willing to pay for an elk hunting permit. We have no influence over the pricing of elk hunting permits. As such, your answers will not be used by the Game and Fish Commission to influence prices. Please answer honestly.

1. What is the maximum amount you would have paid for your elk hunting permit? (circle one) $25 $30 $35 $40 $45 $50 $55 $60 $65 Greater $________(specify)

2. In 1979 in hunt 301 34 hunters out of every 100 hunters killed an elk. In hunt 303 the count was 13 out of every 100. In hunt 351 the count was 6 out of every 100. If you were certain that the success rates for your hunt number would be 1/3 higher than in 1979, that is 45 out of 100 for hunt 301, 17 out of 100 for hunt 303, and 8 out of 100 for hunt 351, what is the maximum amount you would be willing to pay for your elk hunting permit in order to participate in the same hunt as you did in 1979? (circle one)

   $25 $30 $35 $40 $45 $50 $55 $60 $65 Greater $________(specify)

3. If you had to pay $1.50/gal. for gasoline, would you still make the trip? Yes No How about $2.00? Yes No $2.50? Yes No $3.00? Yes No

We realize that the following questions are personal; but, it is necessary for us to have this information for a complete analysis.

1. What was your total household income in 1979? (circle one)

A	up to $5,000	E	$20,001 - 25,000	I	$40,001 - 45,000
B	$5,001 - 10,000	F	$25,001 - 30,000	J	$45,001 - 50,000
C	$10,001 - 15,000	G	$30,001 - 35,000	K	greater than $50,000
D	$15,001 - 20,000	H	$35,001 - 40,000		

2. How many persons are in your household including yourself? ________

Thank you

CONFIDENTIAL

Figure 3.4. Questionnaire from mail survey, page 2.[a)]

a) Reduced from 8½" X 11"

Last week a questionnaire seeking information about your 1979 elk hunting experience was mailed to you. Your name was drawn in a random sample of Arizona elk hunters.

If you have already completed and returned it to us please accept our sincere thanks. If not, please do so today. Because it has been sent to only a small, but representative, sample of hunters it is extremely important that yours also be included in the study if the results are to accurately represent the value Arizona hunters place on elk. Your assistance is greatly appreciated.

Sincerely,

William E. Martin
Professor

M. A. Helfrich
Research Assistant

Figure 3.5. Post card from mail survey.

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF AGRICULTURE
DEPARTMENT OF AGRICULTURAL ECONOMICS
AGRICULTURE BUILDING # 36

June 25, 1980

Dear Elk Hunter:

About three weeks ago we wrote to you seeking information about your 1979 elk hunting experience. As of today we have not yet received your completed questionnaire.

Our research team has undertaken this study because of the belief that citizen opinions should be taken into account in the formation of public policies for the planning and development of our forest areas.

We are writing to you again because of the significance each questionnaire has to the usefulness of this study. Your name was drawn through a scientific sampling process in which every elk hunter had an equal chance of being selected. In order for the results of this study to be truly representative of the values Arizona hunters place on elk, it is essential that each person in the sample return their questionnaire. Thus, we would like to encourage you to complete and return yours today.

In the event that your questionnaire has been misplaced, a replacement is enclosed along with a postage paid reply envelope.

Your cooperation is greatly appreciated.

Cordially,

William E. Martin
Professor

M.A. Helfrich
Research Assistant

Figure 3.6. Cover letter from second mailing of survey.[a)]

a) Reduced from 8½" X 11".

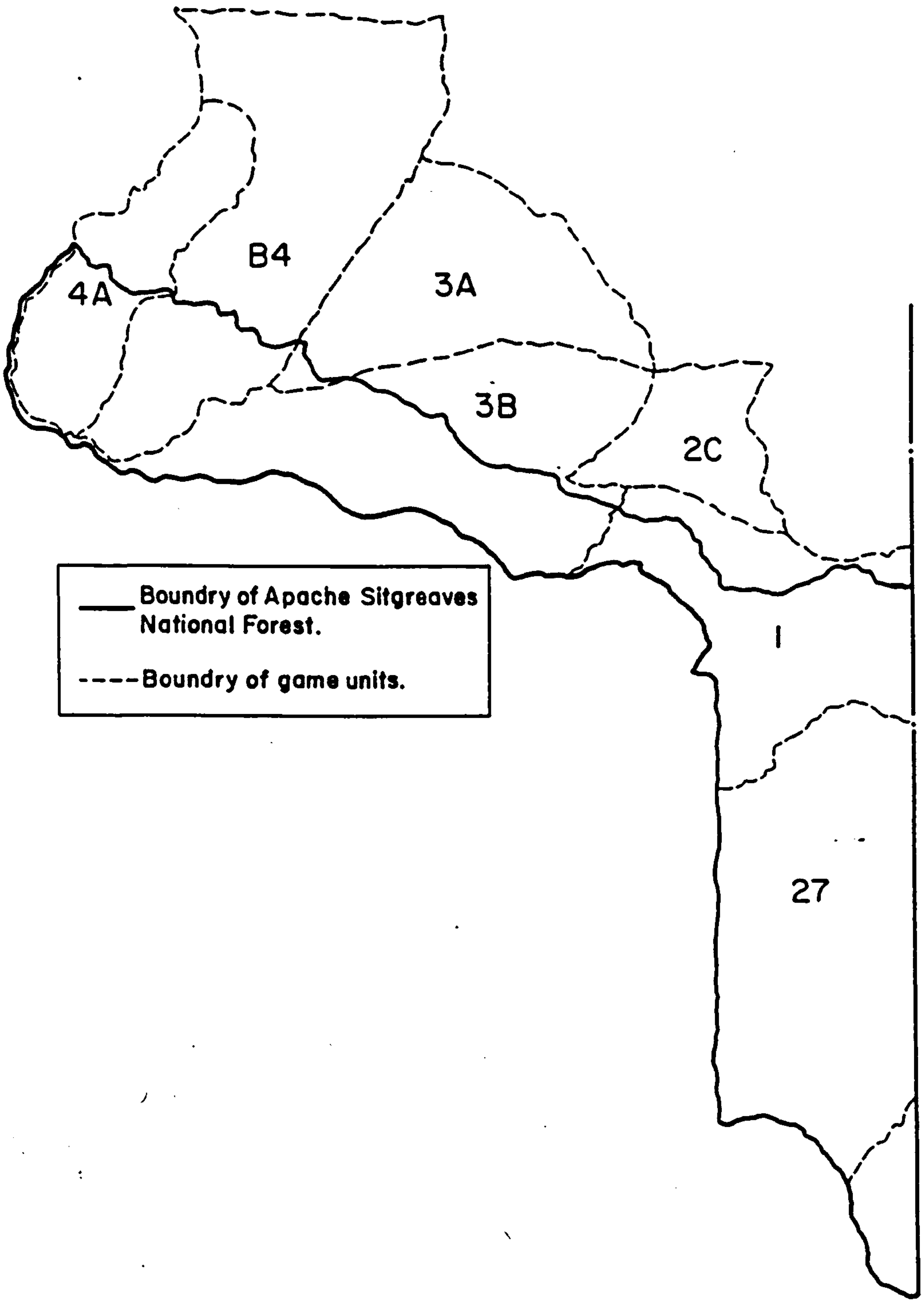

Figure 3.7. Simplified map of hunting units and study area.

grazing is the alternative activity whose value is compared to the value of the land base for elk hunting. Units 2C and 3A lie almost completely if not entirely outside the Forest. The percentage of respondents hunting in those units, however, was insignificant; and, since value comparisons between cattle and elk are made on the basis of an animal unit year of forage the areas coincide closely enough.

Hunt 301 was an early hunt, September 28 through October 3, 1979. Hunt 303 was conducted from November 24 through December 2, 1979. Hunt 351 was an archery hunt only. Its season ran from September 15 through 23, 1979. Estimates of hunting demand are made for each hunt and aggregated across the three.

A questionnaire was sent to every other hunter as found on the list of permittees provided by the Arizona Game and Fish Department. A modified "Dillman Procedure" (Dillman, 1978) was used to procure a large response rate. The procedure was: 1) a questionnaire accompanied by a personal letter explaining the purpose of the project was sent to all persons in the sample (Figures 3.1-3.4). 2) A week later a postcard was mailed to the same persons thanking them if they had returned the questionnaire, reminding them that they had received a questionnaire, and asking that they fill it out if they had not already done so (Figure 3.5). 3) After about a months time, a second copy of the questionnaire, and a second cover letter (Figure 3.6) explaining the importance of the study was sent to those persons who had not yet responded.

Out of a total of 1,150 questionnaires mailed, 754 or 65.5 percent were returned; 66.5 percent of hunt 301's questionnaires, 63.8 percent of hunt 303's and 71 percent of hunt 351's. Figure 3.8 is a

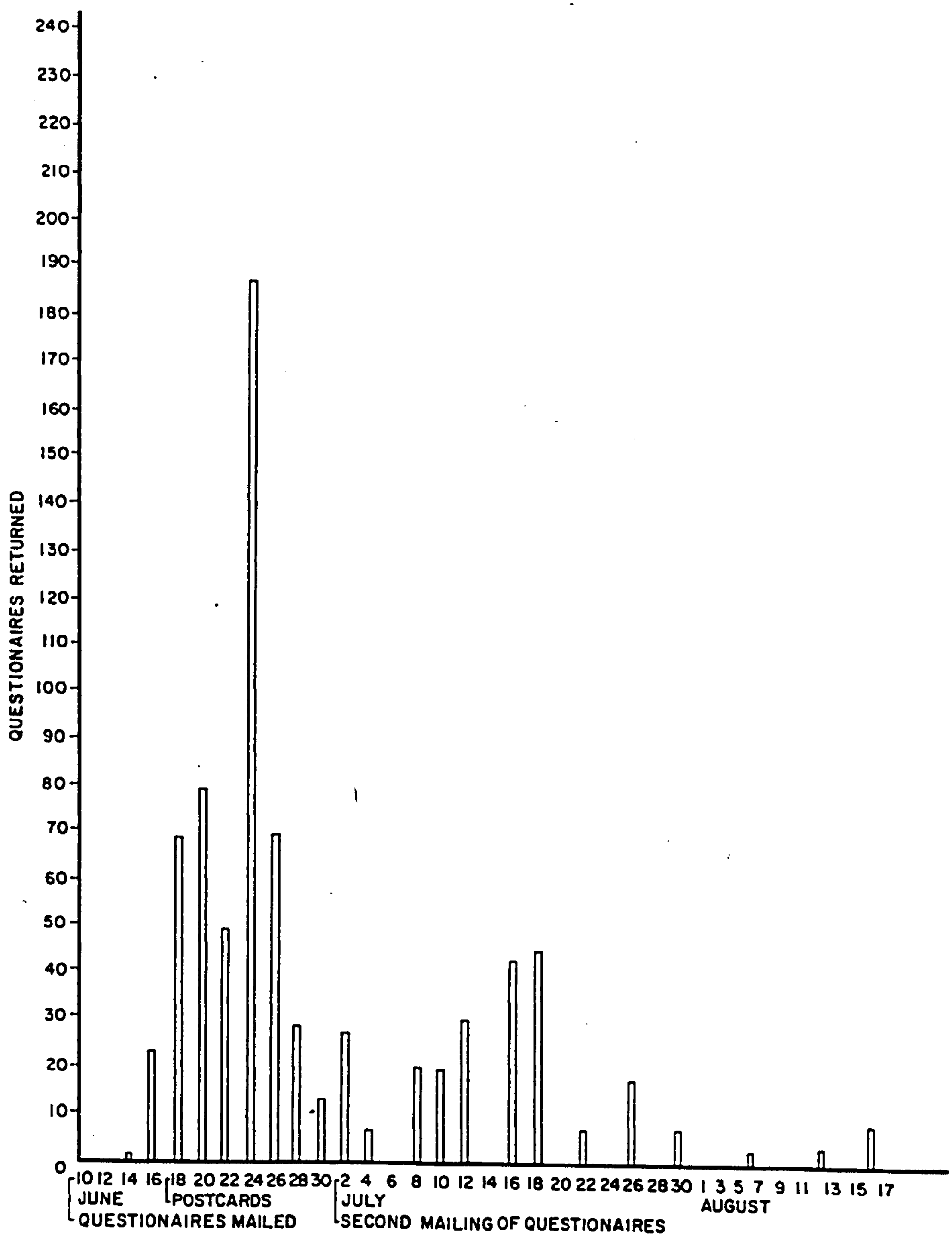

Figure 3.8. Number of questionnaires returned by days.

histogram showing the timing in which the questionnaires were returned. The same data are displayed in Figure 3.9 as a cumulative curve.

The questionnaires were first mailed June 10; the postcards were mailed June 17; and, the second mailing of questionnaires occurred on July 2. There was approximately a six day interim between a mailing and a noticeable upturn in the return of questionnaires. The second mailing of the questionnaires had a definite impact on the return. Point B in Figure 3.9 indicates six days after this mailing. The postcard had a more subtle effect on the return; however, in Figure 3.9, point A does indicate an increased slope about six days after the postcard was mailed.

The Dilman procedure suggests several other measures liable to be conducive to a high return and a more accurate questionnaire. One suggestion was to keep the questionnaire as short as possible. People are more likely to complete and return a survey form when they can sit down and do so in a very short period of time. The questionnaire was only one page front and back. Typing the questionnaire on the front and back of a single page also saved on paper and mailing costs. The enclosed map was printed on the back of the cover letter.

The questions were worded so as to ask for a single quantity or to ask that an answer be circled (Figures 3.3-3.4). It is especially true of willingness to pay questions that the respondents will answer more readily if they are asked to circle the correct response.

Both the willingness to pay and travel cost methods of valuation were considered when devising the questionnaire. The majority of

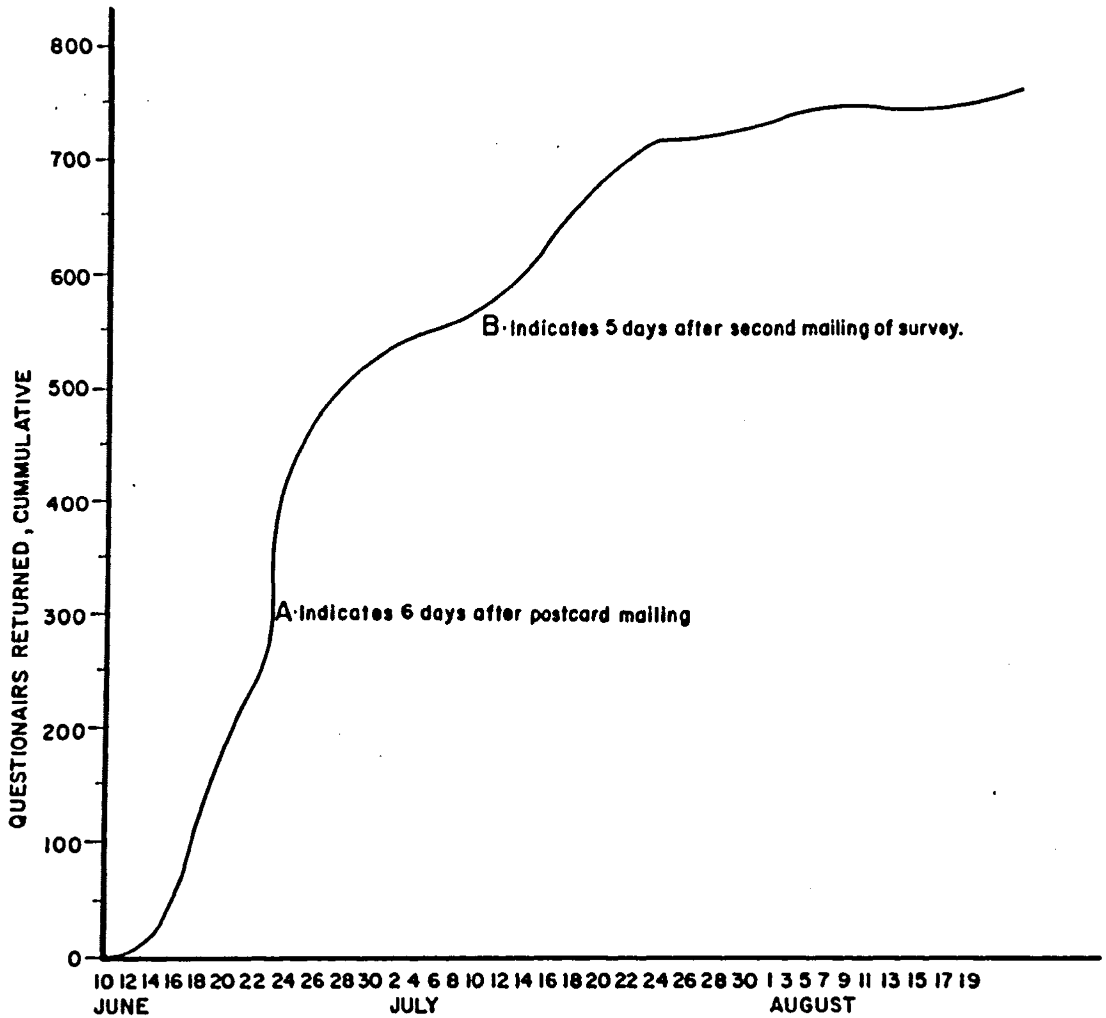

Figure 3.9. Cumulative return of questionnaires.

(A) Indicates 6 days after postcard mailing
(B) Indicates 5 days after second mailing of questionnaire.

questions addressed concerns of those two methods. Other socio-economic questions which the authors felt could have a significant influence on a respondents willingness to pay or travel expenses also were addressed.

When analyzing the data the average benefits were aggregated over the total number of applicants as opposed to the total number of hunters. This aggregation was made because of the unique circumstances of the Arizona elk hunt. Since there are only so many permits available from the Arizona Game and Fish Department, prospective hunters must apply and the lucky applicants are selected through a lottery. An individual also is only permitted by law to hunt once every three years. In effect, if a hunter was chosen to participate in the 1979-80 hunt, he (she) could not apply for a permit again until 1982. There were a total of 7,512 applicants, 3,840 from hunt 301, 3,272 from hunt 303 and 400 from hunt 351.

It is assumed that the mean response of a hunter surveyed would be the mean response of all applicants. Actually, the number of persons sharing this value for elk could be larger than the number of applicants because of the law limiting a person to apply no less than three years after he (she) was drawn. There is no way to determine what this larger population might be; thus, another downward bias in the value of elk is suspected.

CHAPTER 4

THREE APPROACHES TO VALUING ELK HUNTING IN THE APACHE-SITGREAVES NATIONAL FOREST

The Unit Day Value Approach

Unit day values are published annually by the Water Resources Council (WRC) in the Federal Register.[1/] Those for 1979 are shown in Table 4.1 (Table 13 of the May 24, 1979 issue of the Federal Register). To aid in determination of unit-day values the WRC set up five criteria under two categories -- general and specialized recreation. Reproduced in Table 4.2 is Table 12 of the Federal Register, May 24, 1979. It is for "specialized recreation." Elk hunting is a big game hunting experience and is, therefore, classified as specialized recreation.

After all criteria points are assigned and summed, one refers to the WRC Table 13 "Conversion of Points to Dollar Values." The monetary value selected from Table 13 is the unit-day value of the recreation site. One multiplies the specific unit-day value by the estimated annual usage to obtain the estimate of the annual recreation benefits.

Three methods to obtain use estimates are outlined by the WRC: use estimating equation or per capita use curve, capacity method and alternative method. Estimates for this study were obtained from the

---

1. The Water Resources Council was abolished by President Ronald Reagan in early 1981. Exactly how and if its functions will be carried on is not known at present.

Table 4.1. Converting points to value, the unit day value method.[a)]

Table 13.—Conversion of Points to Dollar Values

Activity categories	Point values										
	0	10	20	30	40	50	60	70	80	90	100
General Recreation (Points from Table E-1)	1.07	1.25	1.44	1.66	1.93	2.30	2.48	2.67	2.85	3.04	3.22
General Fishing and Hunting (Points from Table E-1	1.57	1.74	1.90	2.07	2.28	2.51	2.73	2.94	3.06	3.17	3.20
Specialized Fishing and Hunting (Points from Table E-2)	7.50	7.69	7.88	8.06	8.27	9.03	9.80	10.57	11.34	12.10	12.87
Specialized Recreation Other than Fishing and Hunting (Points from Table E-2	4.29	4.65	5.00	5.36	5.72	6.44	7.15	8.58	10.01	11.44	12.87

NOTE.—Unit-Day recreation values may not exceed the values provided by this table.

a) Source: U.S. Water Resources Council, 1979, p. 30237.

Table 4.2. Criteria and point assignments, the unit day value method.[a)]

TABLE 12: Guidelines for Assigning Points for Specialized Recreation

Criteria	Judgment Factors				
a) Recreation Experience 8/ Total Points: 20	Heavy use or frequent crowding or other interference with use	Moderate use, other users evident and likely to interfere with use	Moderate use, some evidence of other users and occasional interference with use due to crowding	Usually little evidence of other users, rarely if ever crowded	Very low evidence of other users, never crowded
Point Value:	0-2	3-6	7-10	11-15	16-20
b) Availability of Opportunity 7/ Total Points: 18	Several within 1 hr. travel time; a few within 30 min. travel time	Several within 1 hr. travel time; none within 30 min. travel time	One or two within 1 hr. travel time; none within 45 min. travel time	None within 1 hr. travel time	None within 2 hr. travel time
Point Value:	0-3	4-6	7-10	11-14	15-18
c) Carrying Capacity 1/ Total Points: 14	Minimum facility development for public health and safety	Basic facilities to conduct activity(ies)	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Point Value:	0-2	3-5	6-8	9-11	12-14
d) Accessibility Total Points: 18	Limited access by any means to site or within site	Fair access, poor quality roads to site; limited access within site	Fair access, fair road to site, fair access, good roads within site	Good access, good roads to site; fair access, good roads within site	Good access, high standard road to site; good access within site
Point Value:	0-3	4-6	7-10	11-14	15-18
e) Environmental Quality Total Points: 20	Low aesthetic factors 5/ exist that significantly lower quality 6/ .	Average aesthetic quality; factors exist that lower quality to minor degree	Above average aesthetic quality; any limiting factors can be rectified reasonably	High aesthetic quality; no factors exist that lower quality	Outstanding aesthetic quality; no factor exist that lower quality
Point Value:	0-2	3-6	7-10	11-15	16-20

FOOTNOTES

1/ Value should be adjusted for overuse.
2/ Value for water-oriented activities should be adjusted if significant seasonal water level changes occur.
3/ General activities include those which are common to the region and which are usually of normal quality. This includes picnicking, camping, hiking, riding, cycling, fishing and hunting which which would be of normal quality.
4/ High quality value activites include those which are not common to the region and/or nation and which are usually of high quality.
5/ Major aesthetic qualities to be considered include geology and topography, water, and vegetation.
6/ Factors to be considered in lowering quality include air and water pollution, pests, poor climate, and unsightly adjacent areas.
7/ Likelihood of success at fishing and hunting.
8/ Intensity of use for activity.

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a) Source: U.S. Water Resources Council, 1979, p. 30236.

survey which generates a use estimating equation, and from information contributed by the Arizona Game and Fish Department.

Criteria points are assigned as follows:

Criteria	Points
a	7-10
b	0-3
c	3-5
d	7-10
e	3-6
Total	20-34

The Principles and Standards indicates that criterion (a) is associated with a change in recreational opportunity; i.e., for specialized hunting and fishing the site "will be given points according to additional considerations of the chances of success . . . ," (U.S. WRC, p. 30237). Since this study is valuing the site in an "as is" situation, 7-10 points are assigned from criterion (a). It is specified that this mid-point of the range is associated with the average catch or bag from the hunt.

Criterion (b) is based on the "likelihood of success at fishing and hunting." The overall success rate for the three hunts was 14.8 percent. Alloting a 20 percent range to each of the five point categories, 0-3 points are assigned to the recreation site from criterion (b).

Use, or overuse, and development of facilities are the concerns of criterion (c). The Apache-Sitgreaves National Forest has some developted facilities very close to the edge of the Mogollon Rim. However, development is not a plus when the concern is big game hunting; it has a negative impact on the value of this activity. It was also reported by a significant number of hunters responding to the survey that lumbering being conducted at the same time as the hunt hindered their satisfaction and drove away elk. From the hunters points of view, lumbering during the elk hunting season is overuse of the area. For these reasons, the site is assigned 3-5 points from criterion (c).

Criterion (d) is based on assessability to and within the area. By referring to the map (Figure 4.1), one can see there are several state and federal roads leading directly or indirectly to the forest from all population centers within the state. Some state roads cross the forest. There are a number of dirt roads off these main roads, some of which are in good condition, but many are poor quality, logging roads. The category most closely resembling this type of access is the mid-range yielding 7-10 points.

Criterion (e) considers the way in which adverse environmental factors effect the quality of the site for specific recreational activities. As noted above, some hunters were adversely effected by logging activities during the hunt. Pollution in general is not a problem, though. The project site is assigned 3-6 points from criterion (e).

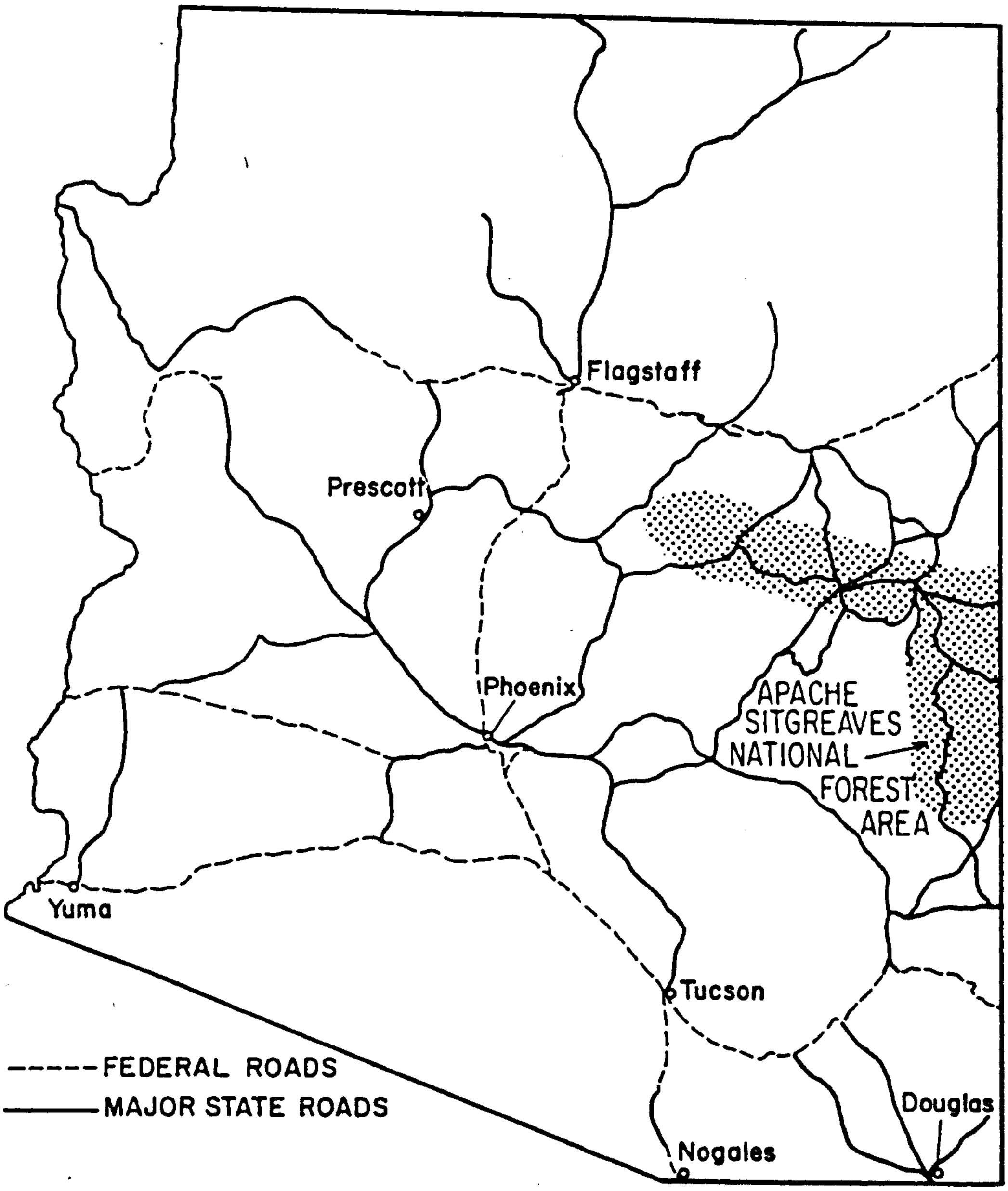


Figure 4.1. Map of Arizona outlining the project area and showing the federal and major state roads.

Total points from all criteria are 20-34, the average being 27 points. Referring to Table 4.2 and interpolating between 20 and 30 points, the unit-day value is $8.02.

Since permits for hunting elk are drawn by lottery, the number of applicants instead of actual hunters is the appropriate estimate of visitors to the site. The applicants times the mean number of days spent hunting and scouting (determined from the survey) yields the estimated number of visitor days. That number, multiplied by the unit-day value, yields the total value of the site when used for the elk hunting activity.

Unit-day value	$ 8.02
Total number applicants	7,512
Mean days at site (includes travel, scouting and hunting time)	7.683

$8.02 X 7,512 X 7.683 = $462,871.86

$462,871.86 = The total value of the project site when used for the elk hunting activity as determined by the unit-day value approach.

Although the systematic UDV procedure outlined by the Water Resources Council was used in making this estimate, selection of the points for each criteria was an individual decision by the author. The table of points provided by the Council, along with the dollar values associated with those points, lack any theoretical basis. The travel cost and willingness to pay approaches to valuing recreation discussed in the next two sections, do have theoretical bases.

The Willingness to Pay Approach

The questionnaire approaches the willingness to pay (WTP) method directly by asking individuals their maximum willingness to pay for an elk hunting permit in an "as is" situation. The interviewees were also asked their maximum WTP given a hypothetical situation in which the hunters are guaranteed a success ratio 33% higher. The results from the later questioning are found in Appendix A.

The original question was:

What is the maximum amount you would have paid for your elk hunting permit? (Circle one)

$25 $30 $35 $40 $45 $50 $55 $60 $65 greater____(specify)

Cumulative frequencies, that is the cumulative percent of respondents willing to pay each amount, were calculated and demand curves derived from the values. The values from each hunt were analyzed separately because the three hunts are three different commodities.

Table 4.3 shows the cumulative frequencies. After plotting this information it was apparent from visual inspection that the relationships were not linear for any of the three hunts. Linear transformations were made before the data were regressed. All three estimated curves were of the form:

$$Y = a + bX^{-c}$$

Y is equal to the demand for permits in cumulative frequencies, and X is equal to the respondents' maximum willingness to pay. The constants a and b were determined by the regression. The constant c, estimated prior to regression, provides the transformation. It was changed iteratively until the highest possible R^2 was reached for each demand

Table 4.3. Respondents' maximum willingness to pay for an elk hunting permit in cumulative frequencies.

Maximum Willingness to Pay	Hunt 301	Hunt 303	Hunt 351
(dollars)		percent	
25	100	99.5	99.9
30	86.8	79.4	87.9
35	72.7	66.6	70.4
40	62.8	60.4	65.1
45	59.5	49.3	56.8
50	58.7	47.3	55.3
55	-	16.3	21.2
60	-	16.0	19.7
65	25.6	15.1	18.9
70	-	-	-
75	17.3	11.1	15.1
100	16.5	8.8	12.1
135	-	2.7	-
137	7.4	-	-
150	6.6	2.5	6.1
200	3.3	1.8	3.0
250	.8	.4	-
500	-	.2	-

curve. Regression was accomplished with SPSS, Statistical Package for the Social Sciences.

The three equations obtained are:

Hunt 301: $Y = 2{,}206.49\ X^{-.90} - 17.72$

$R^2 = .975$

Hunt 303: $Y = 11{,}797.91\ X^{-1.45} - 5.68$

$R^2 = .953$

Hunt 351: $Y = 5{,}153.86\ X^{-1.17} - 12.07$

$R^2 = .933$

The graphs of these curves are shown in Figures 4.2 through 4.4.

Before determining total benefits and consumers' surplus, the cumulative frequencies of each demand curve are transformed into the actual number of applicants. As discussed in Chapter 3, the number of applicants is assumed to represent a population of Arizona residents who maintain a value for elk hunting. Hunt 301 had 3,840 applicants, hunt 303 had 3,272 and hunt 351 had 400.

The total area under each curve is equal to the net social benefits of the elk hunting activity. Since there currently is a twenty-five dollar permit fee, the consumers' surplus is equal to the area under the curve above twenty-five dollars. The total net social benefit is the relevant value.

Each function was integrated between 0 and 100 percent, that is between 0 and the total number of applicants, to find net social benefits. Total permit costs were subtracted to find consumers' surplus. Net social benefits and consumers' surpluses for the three hunts

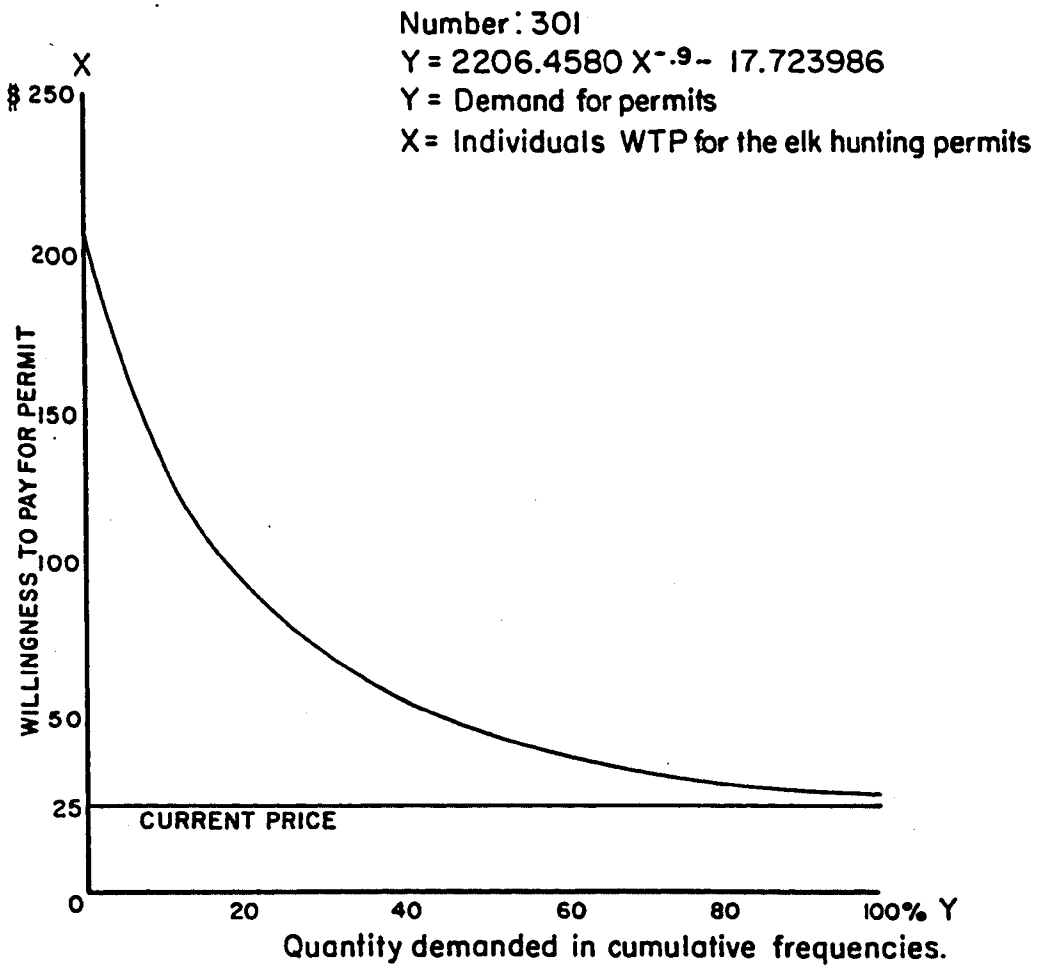


Figure 4.2. Demand for the hunting experience, Hunt Number 301.

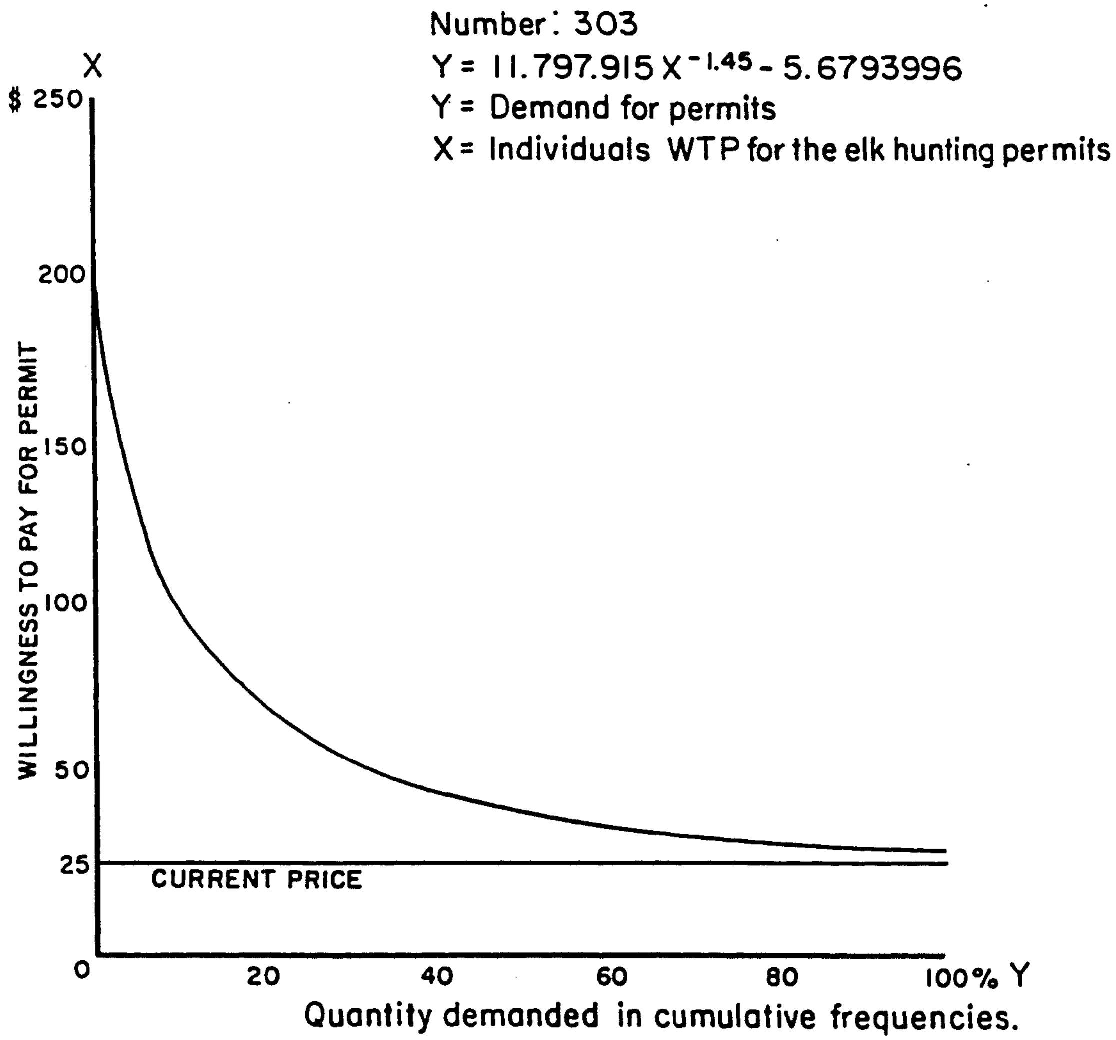


Figure 4.3. Demand for the hunting experience, Hunt Number 303.

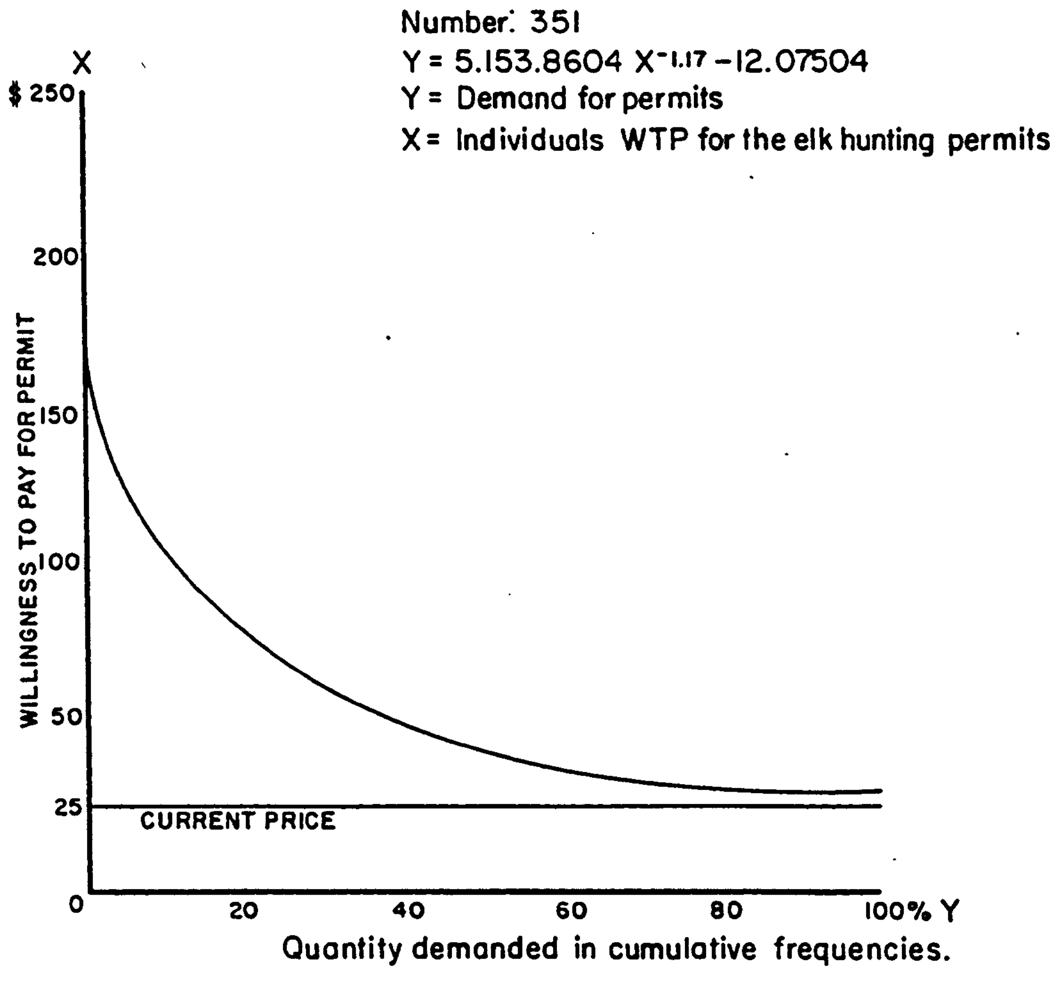


Figure 4.4. Demand for the hunting experience, Hunt Number 351.

Table 4.4. The current value of elk hunting in the Apache-Sitgreaves area: The willingness to pay method.

	Net Social Benefits	Consumers' Surplus
Hunt 301	$247,488	$151,564
Hunt 303	171,715	89,990
Hunt 351	22,497	12,517
Total	$441,700	$254,071

are summed to obtain estimated total benefits and consumers' surplus of the site as used for the elk hunting activity. All values are listed in Table 4.4.

The Travel Cost Method

The Clawson-Hotelling two step travel cost method (TCM) of recreation valuation also was utilized to find a value of elk hunting. In step one, the mean variable costs of hunters participating in the hunt from 14 distance zones are regressed against the per capita demand for permits. This regression yields the demand function for the entire recreational experience. Step two separates, from this total demand, the demand for the site itself by determining the demand from each zone given posited added costs; e.g., increased permit fees.

The 14 distance zones are the 14 counties of Arizona. One point from each county was chosen. This point represents either the major population center of the county or some median point between several population centers. Distances were established from the point of origin in each county along the most direct major routes to each of the seven hunting units. A weighted average of these distances, based on the hunting units utilized by the sample of hunters, established the single distance from each county used in the regression. Figure 4.5 is a map outlining the counties and indicating the selected point of origin from each.

In the survey interviewees were asked their total costs of transportation, lodging, food and various other items (see cost information in Figures 3.3 and 3.4). Each person was asked to give only

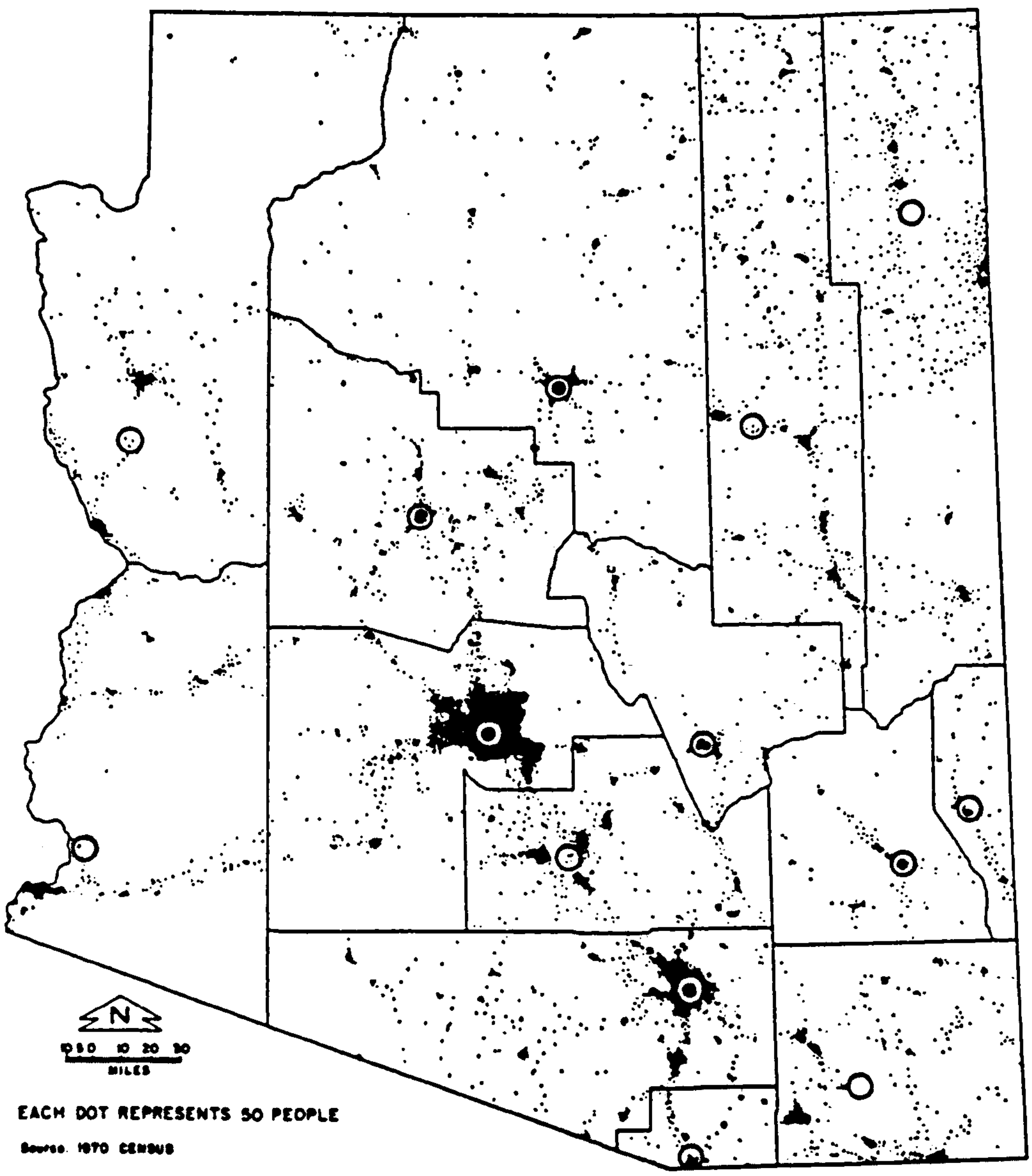


Figure 4.5. Population distribution in Arizona.

his portion of a bill shared with others. Variable costs were summed and the mean variable cost for each zone was found.

Three separate variables, the mean total variable cost, distance and household income, were regressed against the per capita demand from each county to establish a function representing the demand for the entire recreational experience. The variables were added to the regression in a step-wise manner. The step-wise procedure allows one to determine the significance of each variable in the function, and how each variable affects the overall significance of the function. Distance was the only significant variable. In order to be significant at the .95 level, an F value equal to or greater than 3.63 was required. Distance had an F statistic of 9.73; variable cost of .53, and income of .15.

Adding cost and income to the equation lowered the adjusted R^2 of the function. However, there was a high correlation between distance and cost (r = .66). Therefore, it was decided that distance transformed into travel cost might provide a reasonable estimate of cost for the demand equation sought.

In the Principles and Standards, within the section explaining use of the TCM, the Water Resources Council publishes "average variable costs, in cents per mile, to operate an automobile," (U.S. Water Resources Council, p. 30228). Three categories of cost are listed and averaged over the standard, compact and subcompact automobile types. The categories and average cost per mile are shown in Table 4.5.

As with the WTP approach, the best relationship between quantity and cost is non-linear. Because of the requirements for a two-step

Table 4.5. Average variable costs, in cents per mile, to operate an automobile[a)]

Variable Cost Category	Average Cost
Maintenance, Accessories, Parts and Tires	3.6
Gasoline and Oil	2.5
Taxes on Gasoline, Oil and Tires	.7
Total	6.8

a) Source: WRC Estimates for 1978-79.

evaluation procedure, a simple quadratic was used for estimation. This functional form has computational advantages over, and produced an equal R^2 with, the exponential form. The estimated equation is:

$$Y = 17.57 - 1.39\ X + .0294\ X^2;\ \text{Adjusted } R^2 = .673 \qquad \text{(Eq. 4.1)}$$

$Y \times 10^{-3}$ = per capita demand

X = travel cost

In order to be significant at the .999 level an F value equal to or greater than 13.8 is required. The overall F statistic for this equation is 14.38. A plot of the function, along with the 14 observations, is presented in Figure 4.6.

The purpose of step 2 is to develop a demand curve for the resource base itself. One point on this curve is already known, point A in Figure 4.7. Point A depicts the total actual number of visitors to a site, or in this case, the estimated number of applicants, given current costs and zero added costs.

At zero added cost equation 4.1 predicts a number of applicants much larger than the actual number. Therefore, one must work backwards from point A in Figure 4.6. Using the estimated first-step demand curve, a second equation is derived which denotes the change in per capita demand in each county given a hypothetical added cost. Below is that derivation.

Per capita demand for the entire experience $\qquad Y = a + b_1\ X\ b_2\ X^2 \qquad$ (Eq. 4.2)

Per capita demand for the entire experience given an added cost, (A) $\qquad Y = a + b_1(X+A) + b_2(X+A)^2 \qquad$ (Eq. 4.3)

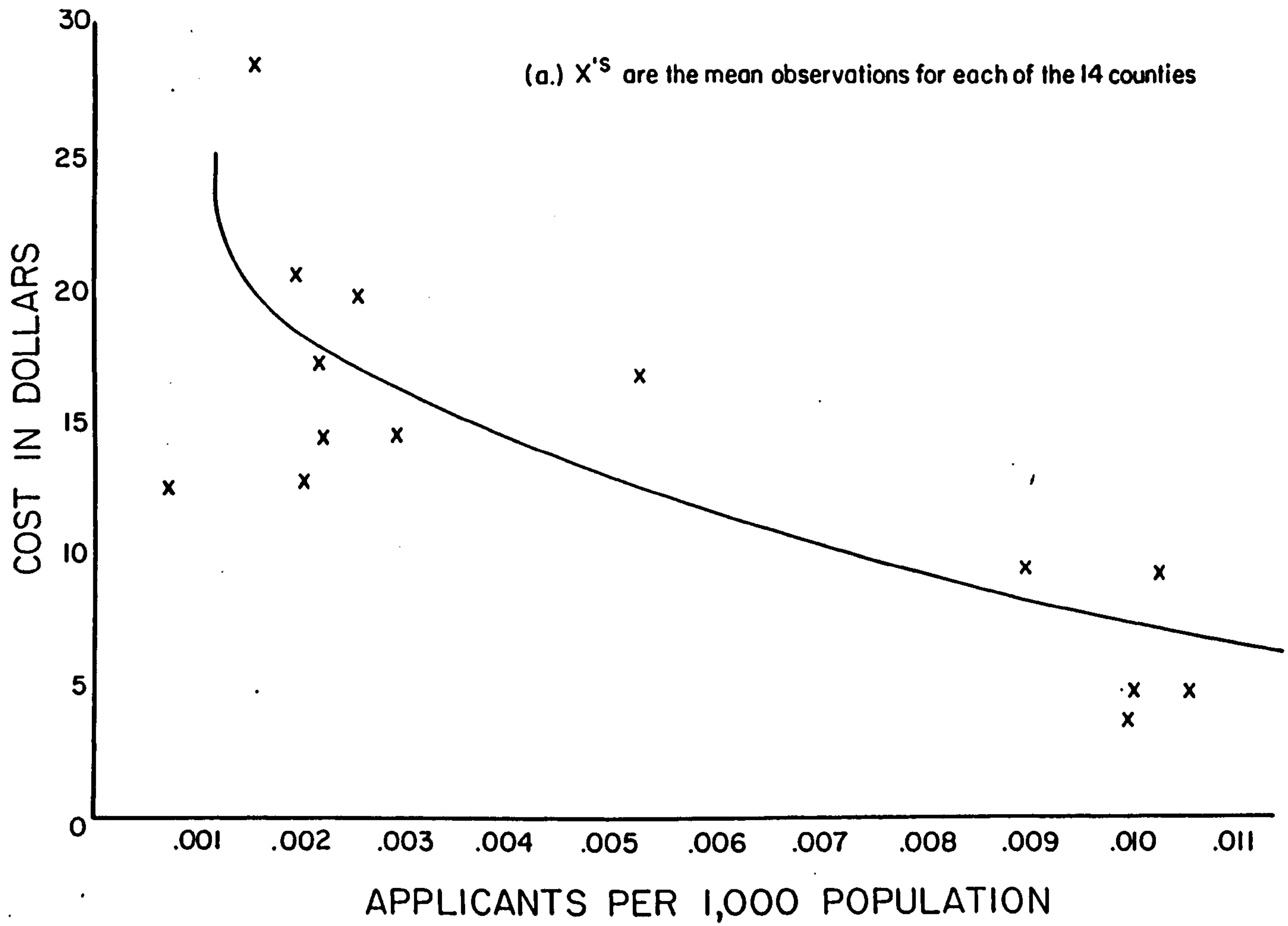


Figure 4.6. Demand for the entire recreational experience of hunting for elk in the Apache-Sitgreaves National Forest: the travel cost method.

The change in per capita demand due to an added cost, = Eq. 4.2 minus Eq. 4.3

$$\Delta Y = b_1 A + 2b_2 \ X \ A + b_2 A^2 \qquad \text{(Eq. 4.4)}$$

The resulting demand curve is displayed in Figure 4.7. The procedure used in deriving this demand curve is partially illustrated in Table 4.6. Column 2 lists the estimated actual number of applicants from each county, the total of which is point A in Figure 4.7. The actual number of applicants for each hunt was known. Based on those figures and the percentage of respondents from each county, the estimated actual number of applicants from each county were derived. Using equation 4.4, columns 3 and 4 were derived.

Column 3 assumes an added cost of $1. The figures shown indicate the change in the estimated actual number of applicants from each county due to a $1 added cost. The total of column 3 is the total change in the estimated actual number of applicants. This estimate when subtracted from the total of column 2 is point B in Figure 4.7. The total of column 4, which assumes a $2 added cost, when subtracted from the total of column 2 yields point C in Figure 4.7. The entire curve is thusly derived.

Since the demand curve for the site predicts the quantity demanded related to added costs above expenses actually paid, the entire area under the curve is the consumers' surplus or the value of the recreation site for a grazing elk. Integration of the demand function yields a value of $36,323.

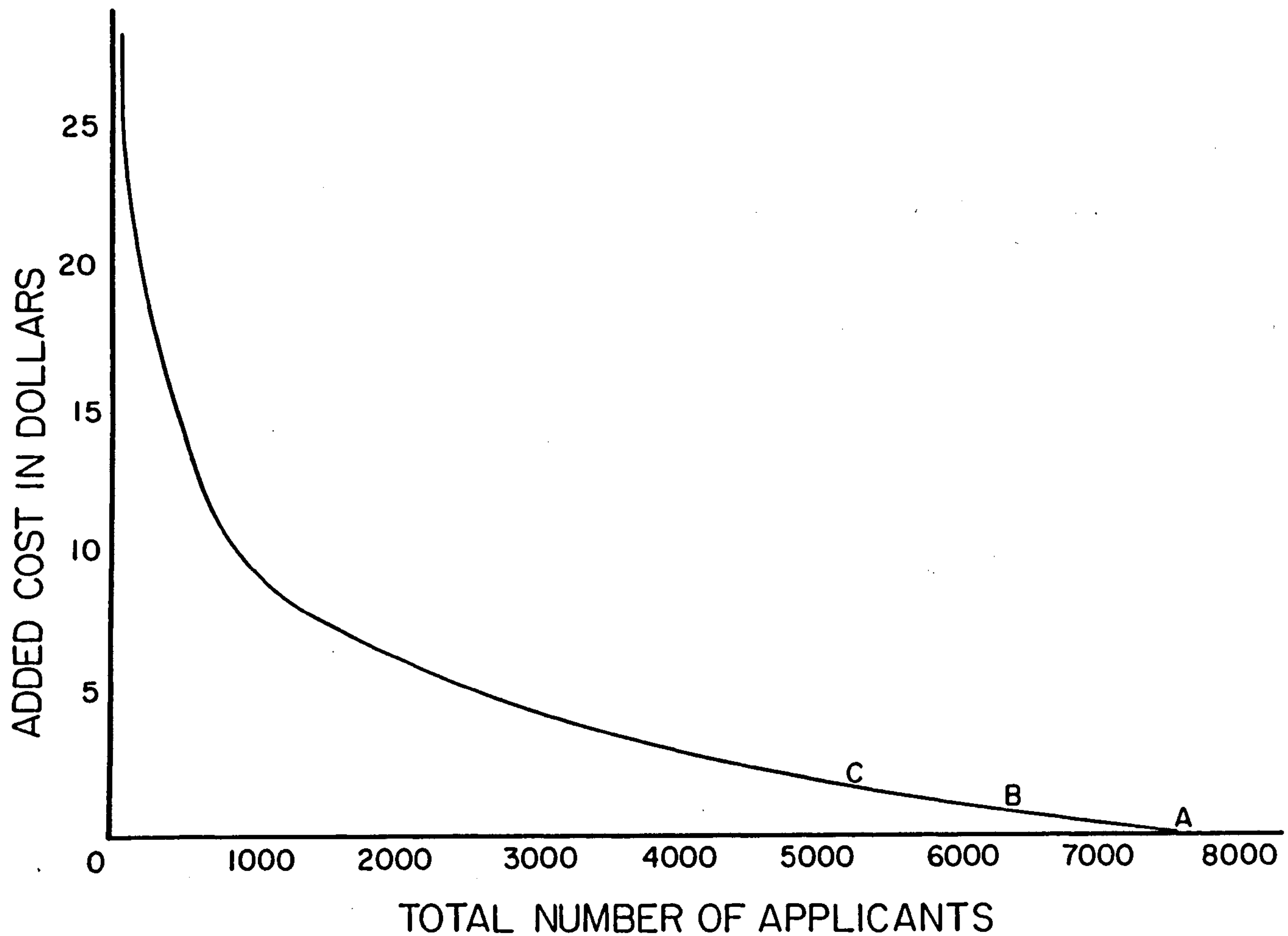


Figure 4.7. Demand for the resource site: the travel cost method.

Table 4.6. Derivation of a demand curve for the site: The travel cost method.

County	Estimated Number[a)] of Applicants at[b)] Zero Added Cost	Change in Estimated[b)] Number of Applicants $1 Added Cost	Change in Estimated[b)] Number of Applicants $2 Added Cost
Santa Cruz	44.44	- 3.44	- 6.08
Cochise	404.09	- 30.20	- 56.75
Pima	1056.86	- 168.50	- 314.68
Graham	296.39	- 18.15	- 35.25
Greenlee	133.97	- 13.12	- 25.70
Yuma	124.34	- 124.34	- 124.34
Maricopa	3118.77	- 674.92	-1287.48
Pinal	269.39	- 49.07	- 93.70
Gila	310.84	- 28.54	- 55.47
Yavapai	113.97	- 34.05	- 65.45
Navajo	1046.49	- 74.14	- 145.12
Apache	746.62	- 51.09	- 99.99
Coconino	51.81	- 45.96	- 51.81
Mohave	72.53	- 8.00	- 13.91
Totals	7537.55	-1323.54	-2375.73
		6214.00	5161.81

a) Number of applicants are not in whole numbers because they are estimates based on the percentage of hunters responding from each county and the known number of applicants for each hunt.

b) Numbers may not sum exactly to total because of rounding.

CHAPTER 5

UNIT DAY VALUE, WILLINGNESS TO PAY AND TRAVEL COST IN RETROSPECT

The Principles and Standards allow a researcher to choose one of three methods to evaluate outdoor recreation benefits. All three methods -- unit day value, willingness to pay, and the travel cost method -- were used to evaluate elk hunting. Chapter 4 describes how each was used. Table 5.1 displays the estimates found by each valuation method. The methods are presented as equivalent by the Water Resources Council. They are found to be quite different in this research. In this chapter some reasons why these differences may have occurred and the applicability of each valuation method to the task of valuing elk hunting is discussed.

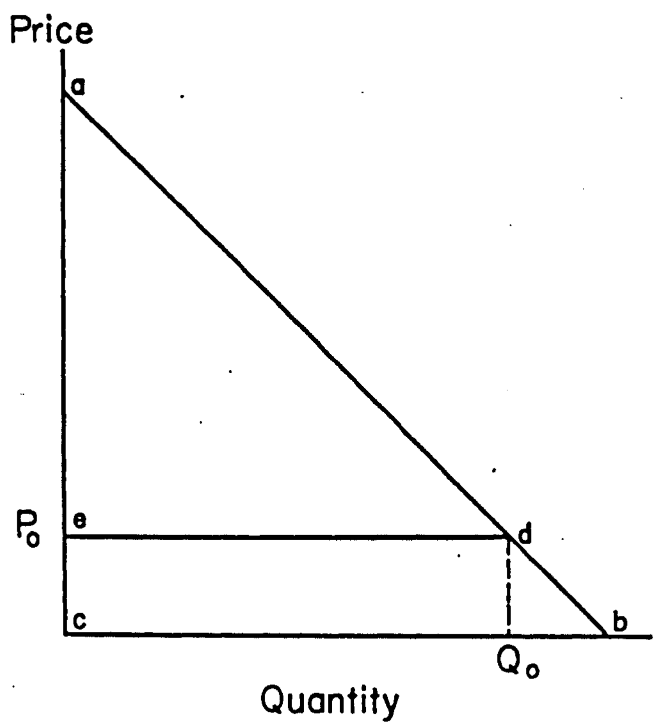
Elk hunting is different from most recreational experiences. In general, a recreator can participate in a favorite activity repeatedly over some period of time. Even if an activity is seasonal, the recreator is not usually limited to a specific number of days within the season. However, elk hunting in Arizona is restricted to 6-8 days once every three years if you are lucky. This characteristic of elk hunting in Arizona makes the use of the unit day value (UDV) and travel cost method (TCM) of valuation inappropriate.

The UDV approach is based on the number of days spent at a site. Obviously, when days are limited UDV cannot best determine value. The

Table 5.1. Values of the Apache-Sitgreaves National Forest when used for elk grazing: Alternative methods of valuation.

Method of Analysis	Net Social Benefits	Consumers' Surplus
Unit Day Value	$462,872	$275,243[b)]
Willingness to Pay	$441,700	$254,071
Travel Cost	$233,950[a)]	$ 36,323

a) and b) These values were not derived using the method of analysis indicated. No matter how the demand curve is derived, however, the total demand curve will look like Figure 5.1. It will consist of an area of net social benefits (adQoC0 and an area of consumers' surplus (ade). In all methods of analysis the cost of entering the site is the same, consumers had to pay a $25 permit fee; and the number of applicants is constant. Area edQc is the total cost of elk hunting to the consumer. This area was valued at $187,629 in the WTP approach to valuation. Subtract $187,629 from the value of net social benefits determined by the unit-day method; and, add to the value of consumers' surplus determined by the TCM to complete Table 5.1.



P_o = current admission price

Figure 5.1. Hypothetical demand curve for a recreation site.

UDV method also assumes that the more days spent recreating the greater will be the value. The most successful hunters, however, bag an elk on the first or second day then go home. If an elk hunter were permitted, as in some other wild game seasons, to hunt as many times as wished over a season, then the UDV assumption might be valid. However, the assumption seems to be a contradiction when the hunter is limited to one hunt 6-8 days long and one catch.

The TCM bases value on the amount one spends to enjoy an experience, i.e., travel costs, food, lodging, etc. There is a strong basis to this theory. However, given the circumstances of elk hunting in Arizona, one is led to believe the hunter may value the experience greater than what he (she) spends in variable costs. It seems then the only way to arrive at the value of elk hunting is to ask participants directly. The willingness to pay (WTP) approach asks hunters directly what they are willing to pay for the experience, how much they value it.

Another problem with the TCM used to value elk hunting is in the empirical data themselves. The theory specifically states that all variable costs of the trip should be included in the demand for the total experience. However, when valuing elk hunting the only significant variable was distance which was transformed to variable transportation cost.

The demand curve for the recreation site derived in the TCM of valuation (Figure 4.6) indicates that the most added cost an individual would be willing to bear is about $28. In the WTP analysis, when participants were asked directly their willingness to pay for a permit, values greater than $200 were obtained. Some hunters, therefore, would be willing to pay an added $175 (the cost of a permit is $25).

Brown and Nawas (1972, 1973) and Gum and Martin (1975) present an argument which may be used to explain why the TCM estimates in this study may be low. The original Clawson-Hotelling TCM specified that estimates be based on mean responses from distance zones. When variables are averaged, as such, there is a tendency for the distance and variable costs variables to appear highly correlated; in which case, only one of the variables can be used in the model. The variable chosen will create a specification bias. When individual responses are used instead of average values there is not as great a tendency for correlation between the variables. Both distance and variable cost can then be used in the equation, resulting in a better specified demand function. Brown and Nawas, and Gum and Martin showed that the estimates of value from the improved demand function, derived from individual responses, will be larger than estimates from a less specific function with specification bias.

Since each elk hunt applicant could take only one or no trips, and the number of days is irrelevant, the individual response approach could not work. Thus, the procedure followed in this analysis necessarily was the basic Clawson-Hotelling TCM. Variables were averaged for 14 distance zones. The original regression resulted in a correlation between distance and variable cost; variable cost was dropped because of lower significance. One may, therefore, assume that the final estimate of value from the TCM is an underestimate.

The WTP approach to valuation is not without its biases, as discussed in Chapter 2. It is apparent, however, that it yields the best estimate of the value of elk hunting in Arizona. WTP asks hunters directly how much they value the elk hunting experience, and demand curves are derived from individual responses. The resulting demand curves explain a large proportion of the variance. The WTP results are used throughout the remainder of this study.

CHAPTER 6

VALUING CATTLE RANCHING IN THE APACHE-SITGREAVES NATIONAL FOREST

Consumers' Surplus

The estimation procedure followed to find the consumers' surplus for cattle production is based on a study by Tinney (1977) and the follow-up article by Martin, Tinney and Gum (1978). A reduction in the Arizona beef crop is posited and the resulting loss in consumers surplus to U.S. beef consumers is estimated. The costs of a reduction in the Arizona beef crop are stretched across the entire U.S. market. However, it could be argued that to make the value of the land for cattle production comparable to the value of the same land for elk production only the costs to the people of Arizona must be considered. Since the elk herd is managed by the state and most elk hunters are residents, it could be argued that the relevant value for the beef herd must also be related to Arizonans. This value will be compared to the value of the Apache-Sitgreaves elk herd to consumers nationwide.

Figure 6.1 depicts a theoretical demand curve for cattle production in the United States. The shaded area is a decrease in consumers' surplus due to a reduction in the quantity produced and an increase in price resulting from the elimination of cattle production in the Apache-Sitgreaves National Forest.

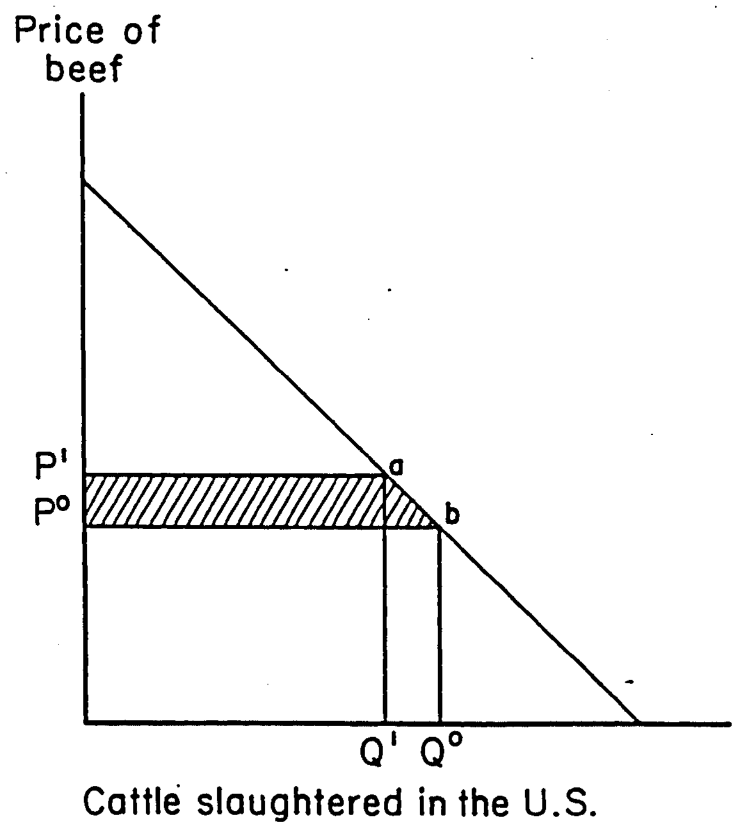


Figure 6.1. Theoretical demand for beef cattle in the United States.

The data used to estimate the quantity of beef produced on the Apache-Sitgreaves Forest are shown in Table 6.1. The number of cattle slaughtered in the United States is used to find the retail beef production nationwide. The contribution made to that production by the Apache-Sitgreaves is estimated by using the saleable calf crop from the forest. Most calves are sold to a feed lot and fattened before being slaughtered for market. It is assumed here, as in Tinney (1977) and Martin et al. (1978), that all saleable beef calves are ultimately sold as choice steers of an average weight of 1000 pounds.

The change in price depends upon the elasticity of demand, the inverse of which is the price flexibility. The price flexibility coefficient indicates the percentage change in price due to a one percent change in quantity. The price flexibility utilized in this study was estimated by Tinney (1977) as -1.71. The percentage change in the price of beef is the product of the estimate for price flexibility times the percentage change in quantity. The price change is positive since the price flexibility (-1.71) and the percentage quantity change (-.015) are both negative. The actual average price of retail beef in 1978 was $1.819/lb. The adjusted average price after the decrease in quantity is $1.8194355/lb. Martin et al. assumed that the demand for beef was linear over the section concerning a 100 percent decrease in the Arizona beef crop. They explain that the Arizona beef crop was only .54 percent of the U.S. beef crop in 1975; and, by 1978 Arizona contributed only .363 to the U.S. beef crop. The Apache-Sitgreaves National Forest contributed .015 percent to the U.S. beef

Table 6.1. Some statistics used to derive the consumers' surplus of beef production on the Apache-Sitgreaves National Forest.

	No. of Cattle Slaughtered, or, Saleable Beef Calves	Retail[c] Beef Production	Percentage Change in Quantity
	(1,000 head)	(million lbs)	
United States	39,552.00[a]	17,578.667	
Apache-Sitgreaves	5.88[b]	2.163	
U.S. minus Apache-Sitgreaves		17,576.054	.014

a) The number of cattle slaughtered in the U.S. in 1978 from <u>Agricultural Statistics 1979</u>, Table 460, pg. 310. The statistic includes Federally inspected beef and other; excludes farm slaughter and calves.

b) The number of saleable beef calves from the Apache-Sitgreaves National Forest based on the percentage of Arizona range cattle and calves found in the Apache-Sitgreaves, (2.9%) data from <u>Arizona Agricultural Statistics</u> 1979, (pg. 51) and the <u>Western Livestock Round-Up</u>.

c) The average conversion of live weight to retail weight is 2.25 to 7, Uvacek, 1967 in Tinney 1977. The average live weight of a steer is assumed to be 1000 lb.

crop in 1979. Therefore, the assumption of linearity is maintained for this study. A single price flexibility can then be used to determine the change in price.

Under the assumption of linearity and a single price flexibility, the following formula determines the change in consumers' surplus; the quantity is the shaded area in Figure 6.1. Calculations are based on the actual number of cattle grazed in the national forest as opposed to the allotted number.[1]

$$CS = \Delta P(Q^o - \Delta Q) + 1/2\ \Delta P \cdot \Delta Q$$

CS = Change in dollars of consumers' surplus = \$7,654,940

ΔP = Change in average U.S. retail price per pound of beef = \$.0004355

Q^o = Pounds of U.S. retail beef production = 17,586.667 million pounds

ΔQ = Pounds of Apache-Sitgreaves retail beef production = 2.613 million pounds

The value calculated is the change in annual consumers' surplus nationwide due to an elimination of the Apache-Sitgreaves cattle crop. The annual change in consumers' surplus to the people of Arizona is also sought. To find this value the value to consumers nationwide is put on a per capita basis:

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1. The actual number of cattle grazed is somewhat less on the average than the allotted number, due to a fear of overgrazing which would cause the allotments to be decreased. The Forest Service in Springerville provided the estimates based on field observation.

$$\text{Per capita CS} = \frac{\text{CS}}{\text{Pop. of U.S.}} = \frac{\$7,654,940}{217,513,000} = \$.035$$

The annual per capita value multiplied times the population of Arizona yields the annual value of the Apache-Sitgreaves cattle crop to the people of Arizona: CS to Arizona = $.035 X 1,787,620 = $62,913. Population estimates are from Rand McNally (1978).

Producers' Surplus

Calculation of the producers' surplus for cattle ranching in the Apache-Sitgreaves National Forest is based on the value of the forage itself. Martin and Snider (1980) studied the value of forage in the Salt-Verde Basin of Arizona. The Apache-Sitgreaves National Forest lies partially within the Salt-Verde Basin. Therefore, it is assumed that the area studied by Martin and Snider is similar enough to Apache-Sitgreaves to warrant using their results as a basis for the producers surplus in this study.

Martin and Snider developed budgets and determined forage values for four representative size ranches, 151 animal units (AU), 229 AU, 468 AU and 701 AU. The weighted mean size ranch in Apache-Sitgreaves is 149 AU. Therefore, the values of forage determined for the 151 AU ranch are utilized.

Martin and Snider show the values of forage per animal unit in both the short run and the long run. As well, they determined these values under the alternative assumptions of $.58, $.80, and $1.00 per pound for yearling steers. The aggregate producers' surplus based on the short run and long run values, and on 58 and 80 cents per pound for yearling steers are calculated for this study.

The short run, assumed by Martin and Snider to be one year, is that period of time in which a producer need only cover his variable costs of production. Variable costs, such as fuel and feed, are readily calculated. Their values are simply "observed" price times "observed" quantity.

In the long run all costs of production must be covered by revenues, variable costs as well as accounting costs. Accounting costs include depreciation on buildings and equipment, return to management and return to capital. Accounting costs are more difficult to measure accurately. Therefore, the short run values of forage determined by Martin and Snider are assumed to be more accurate.

Examining Table 6.2, the long run values of forage are negative under both price assumptions, leading to negative producers' surplus values. There are speculative reasons for these results. Martin and Jefferies (1966) conclude that the sale price of ranches in Arizona have been high relative to what they would have been had the ranches been sold solely for the purpose of raising cattle and selling beef for profit. The economic rent was higher than it theoretically should have been.

Smith and Martin offered an answer to this dilemma in 1972. They posited, after interviewing a cross-section of Arizona ranchers, that the average rancher obtained utility from simply being a rancher. Because of this "psychological benefit" Arizona ranchers are willing to

Table 6.2. Producers' surplus of land utilized for cattle[a] grazing in the Apache-Sitgreaves National Forest.

(A) $.58 per pound for yearling steers.

Time Frame	Value per[b] Animal Unit of Forage	Total Loss to Producers
Short run	\$7.60	\$132,855
Long run	\$(-)86.69	\$(-)1,515,427

(B) $.80 per pound for yearling steers.

Time Frame	Value per[b] Animal Unit of Forage	Total Loss to Producers
Short run	\$62.57	\$1,093,785
Long run	\$(-)31.72	\$(-)554,497

a) The average carrying capacity is assumed to be 8 animal units per section.

b) Values obtained from Martin and Snider (1980, p.35).

accept a low return to management and a return to investment below the market rate of interest.

The negative long run values of forage found by Martin and Snider were made assuming (among several things) that "the value of a ranch . . . strictly related to its income producing potential, . . . investor requires a return on his investment equal to the market rate of interest . . . ," (p. 6). Since it is known that ranchers are willing to accept a return below market, one may expect long run returns to forage (the long run value of a ranch) to be negative when market rates of interest are used in the analysis. However, there is no way to decide on a lower interest rate to use; the values of forage given are the best estimates. If the utility value ranchers get from ranching could be included in the long run returns, those values may not be negative.

In each case given in Table 6.2, the value per animal unit of forage was multiplied times the animal units of grazing allotted in the Apache-Sitgreaves National Forest. There were approximately 17,481 animal units of grazing allotted in 1978, as obtained from the National Forest Service.

The producers' surplus in the short run using $.80 per pound for yearling steers is the value utilized in the remainder of the analysis in this study. For reasons given by Martin and Jefferies (1966) and Smith and Martin (1972) (see discussion above), it would be unreasonable to use the negative long run values. The value found ($1,093,758) is a loss to producers in the Apache-Sitgreaves.

There are, as discussed in Chapter 2, also producers who will gain as a result of an elimination of the Apache-Sitgreaves cattle crop. The procedure followed to determine this value is developed by Martin (1981) based on data in Martin and Snider (1980) utilized above. The price of beef will rise when production is cut back; but, since demand is very inelastic, the quantity demanded will decrease only slightly. All producers outside the area in which production is limited will gain from this price increase.

By eliminating the Apache-Sitgreaves cattle crop the U.S. beef crop is cut by .015% or 5,880 head, and 2.613 million pounds of retail beef. The price will rise by .031% or .0245 cents per pound, assuming an 80 cent base. Referring to Table 6.3 (Table 18 in Martin and Snider, 1980), the gross average sales of a 151 animal unit (AU) Central Mountain unimproved ranch, assuming .80 per pound for yearling steers, is $32,740. If the price increased by .0245 cents the gross sales would be $32,840. Since operation costs are not affected, one can assume that the variable costs remain the same ($22,479). The short run value of an animal unit year (AUY) of forage rises to $63.18, an increase of $.61.

Net Social Value

In order to sum the values of the Apache-Sitgreaves cattle crop to consumers and producers, the value to consumers is converted to value per AUY of forage. The total consumers' surplus to consumers across the U.S. is $7,654,940; to the consumers of Arizona it is $62,912. The AU's allotted for grazing in the forest total 17,481. It

Table 6.3. Values of forage.

	Price of Yearling Steers ($/lb)		
	.58	.80	1.00
Cattle Sales (8 AU/Section)	23,725	32,740	40,807
Net Returns Above Variable Costs (8 AU/Section)	1,246	10,261	18,328
Net Returns To Forage (8 AU/Section)	(-)14,217	(-)5,202	2,865
Short-Run Value per Animal Unit	7.60	62.57	111.76
Long-Run Value per Animal Unit			
(8 AU/Section)	(-)86.69	(-)31.72	17.47
(9 AU/Section)	(-)71.88	(-)20.44	28.42
(7 AU/Section)	(-)105.85	(-)45.42	3.62

is assumed, as Martin and Snider calculated, that it takes about 108 AUYs of forage to sustain 100 allotted AUs given a mix of bulls, horses, cows, calves, yearling heifers and yearling steers. Therefore, 18,879 AUY of forage are allotted in the Apache-Sitgreaves. The value of an AUY of forage in the Apache-Sitgreaves for grazing cattle on a nation-wide scale is $405.47. The same unit of forage is valued at $3.33 by the consumers of Arizona only.

The net social value is the loss in consumers' surplus minus the gain to producers plus the loss to producers. In Figure 2.6 this net change in surplus equals ((A+B) -A) + (C). Empirically, A + B = $405.47 or $3.33 depending on the scale; A = $.61; C = $62.57. Net social value of an AUY of forage in the Apache-Sitgreaves for grazing cattle if $467.43 or $65.29. A summary of these values appears in Table 8.2.

CHAPTER 7

THE BIOLOGICAL CHARACTERISTICS OF ELK AND HOW THEY COMPETE WITH CATTLE

In order to define a production possibilities frontier between cattle and elk it is necessary to understand the biological and habitual characteristics of each.

The literature tells us that elk need a special environment. In days gone by, barring any natural disasters, there was ample habitat to maintain vast elk herds. Man has limited elk in various ways. As a result of livestock competition and year long hunting with dogs, some species of elk became extinct in the early 1900s. The Arizona Game and Fish Department reports (Jan.-Feb., 1970), there were no elk in Arizona from the late 1890s to 1913. In 1913 the Winslow Elks Lodge obtained 86 Wyoming Rocky Mountain Elk and transplanted them in the Sitgreaves National Forest south of Winslow. Two hundred seventeen more elk were transplanted in various areas of the forest between then and 1928.

Characteristics

Elk Size

The Rocky Mountain Elk are the type now found in Arizona. Though they are transplants, they have adapted well and multiplied. The Rocky Mountain are the third largest type of elk found in North America. The maximum weight of this elk, which stands 49-59 inches at the shoulder, is a little over 1000 pounds. Murie (1951, p. 69) lists the average buck as weighing between 600 and 700 pounds; Schmidt (1978, p. 14) found the average buck weighted 700 pounds. Elk lose weight in winter and so are expected to be lightest in the spring and heaviest in late summer. Both sources found the mature female elk (cow) weighed an average of 500-525 pounds (Murie, p. 71; Schmidt, p. 14).

Sex Differential

The size of the bull vs. the cow elk becomes important in a study of production possibilities. This importance is more apparent when one considers the somewhat unique characteristic sex differential in elk. Namely, there are more adult cows than bulls. The differential occurs basically for two reasons. One, it was found that bulls tend to disperse more from the area in which they were reared than females. Two, bull elk die younger than cows. The bull experiences a depletion of fat reserves during the autumn breeding season. Thus, they have a more difficult time surviving in the winter months. The life expectancy of a cow is 21 years, that of a bull is only 14 years.

The naturally low number of bulls does not hinder the population expansion. One bull can mate with many cows. Thus, the low number of bulls has a positive consequence; more food and space is left for calves and cows.

Statistics on the sex ratios of elk are given in several texts, and show some conflict. Flook cites one sex ratio counted in October and November as 37 males: 100 females. However, he explains, ". . . as the distribution of females coincide more closely with areas of low elevation and ready access to observers than did that of males, data on sex ratios from those areas are believed biased in favour of females. More reliable population data were obtained from an enclosed 50 square mile area of uniformly low elevation . . . " (Flook, 1970, p. 5). The sex ratio in this study was found to be 85 males: 100 females. A separate study published eight years later, funded by the Wildlife Management Institute, determined the average sex ratio to be 35-45 bulls: 100 cows: 35-65 calves (Schmidt, p. 26).

Primary Habitat Factors: Forage, Water and Cover

The Rocky Mountain Elk like other subspecies of elk is a herbivore. It eats only plant matter. More specifically, the elk is a grazing animal. The bulk of its diet consists of grasses and sedges, though traces of browse have been found in the stomachs of elk consisting usually of Douglass fir, but sometimes spruce, juniper, or sage, rarely willow or aspen. Elk prefer grass but will turn to browse when the grass has been grazed down or snow-covered. Some studies have shown browse as the predominant plant found in elk stomachs. They will eat the species most abundant in any area, many say. In this respect they are more omnivorous than many wild grazing animals, leading the way to competition with many species.

Elk respond to topographic conditions and to the arrangement of vegetation. For example, ". . . moderately steep south slopes rather than north slopes . . ." (U.S. Department of Agriculture, Wildlife Habitats . . . , 1979, p. 107) are preferred in winter because of the warmer temperatures and less snow.

An optimum elk habitat includes cover areas, forage areas and water. Studies by Reynolds (1962, 1966) and Harper (1969) found that a ". . . ratio of 40 percent landtype in cover and 60 percent in forage areas of proper size and arrangement approximates optimum habitat in the Blue Mountains (of Oregon and Washington)," (U.S. Department of Agriculture, Wildlife Habitats . . . , 1979, p. 109). The authors feel the ratio is applicable to any silviculture. The ratio of land types for optimum elk habitat should hold true in the White Mountains of Arizona. The other factor necessary in an optimum environment is water, especially on summer ranges. Various studies have shown that elk made "disproportionate" use of areas with potable water within a very short distance, (Ibid., p. 109). The rule derived from those studies is that optimum elk habitat has potable water within 0.5 miles of any point.

Summer habitat is usually ample for a given population of elk. The literature over the past 30 years has shown that it is the shortage of winter food which limits an elk population. Extensive die-offs of elk population due to starvation in winter months were recorded as far back as 1705 and 1755 in the Eastern United States (Trippensee, 1948, p. 342). Trippensee reports that when elk are restricted on winter range they tend to damage fences and orchards and raid forage meant for domestic livestock.

In studies by Grimm in Yellowstone National Park it was found an elk needed "0.5 acre per month for 6 months during the winter season, or 3 forage acres per winter period per animal to carry it on a sustained range basis" (Ibid., p. 342). After examining a 150,000 acre range Grimm felt 7,756 elk could be sustained if no other browsing or grazing animal were present; or, about 13.4 elk per secton.

Competition for Survival

Competition of elk with domestic cattle is very real where both occupy the same range. Cattle share with elk a taste for a wide variety of plants. There is, however, room for some complementary living between cattle and elk. Cattle tend to avoid high rough slopes when searching for food, spending much of their time grazing on stream bottoms and in lush meadows. Elk do graze on the slopes and reach higher country. One must not interpret this complementary arrangement to mean that elk and cattle feed "exclusive of each other on the range". The arrangement only works to diminish the competition.

There is also a sociological competition so to speak. An on-going study at the University of Arizona headed by Paul Krausman is looking at this competition. It is hypothesized that as cattle are placed on a range, elk will stay to a point given an ample food supply. However, after so many cattle per section are placed the elk will move out of the area whether there is forage enough for them or not. They are crowded out.

Elk also compete with horses but to a much lesser extent than cattle. Horses are primarily grass eaters and do not share the catholic tastes of cattle and elk.

A quite different problem arises when one considers the food competition with domestic sheep. Sheep are as omnivorous as elk; as well, they can travel any type of terrain that an elk can. Thus sheep more directly compete for food with elk than do cattle.

Elk also compete with deer to a great extent. If a forest is managed for a maximum elk population the deer population will decrease as elk out compete deer for food.

A discussion of competition in the elk environment would be incomplete without mention of man. Man has limited elk grazing land by their shear expansion into forest areas with farming and ranching. Within the now limited habitat of the elk, forest management practices including fire prevention have allowed much land to grow toward a climax forest. Elk need grass and shrub, for the most part not found in a climax forest. Timber sales cause displacement of elk. There is an increase in poaching due to the increased number of roads and vehicular accessibility. Elk also get caught in fences. And, high activity areas such as popular recreation sites generally drive elk away. However, man can be a complimentary competitor if he wants to. Proper timber harvest practices and controlled burning can be used to improve elk habitat.

Elk vs. Cattle: Carrying Capacity

Murie reviews a very interesting experiment performed on the National Elk Refuge in Wyoming. The purpose of the study was to determine the "food requirements per day, per individual and per hundred weight over a period of 43 days" (Murie, 1951, p. 293). They penned both calves and adult elk, weighing the animals at the beginning of the experiment and again at the end. At the same time a neighboring rancher fed four head of Hereford cattle (three cows and one steer) from the same "hay shed."

The following results were obtained (Murie):

Elk calves consumed 7.8 lbs. ea., or 3.11 lbs. per cwt.

Adult elk consumed 12.5 lbs. ea., or 2.5 lbs.per cwt.

Elk, all ages, consumed 9.8 lbs. ea., 2.7 lbs. per cwt.

Adult cattle consumed 31 lbs. ea., or 3.6 lbs. per cwt.

The figures suggest, approximately, a ratio of 2½ elk to one head of domestic cattle when looking at the adults only. In comparison of elk of all ages to adult cattle, the ratio is about 3 to 1. A number of other studies have substantiated these estimates, as cited in Murie.

Conditions Specific to the Apache-Sitgreaves National Forest

To develop the production possibilities frontier between cattle and elk on the Apache-Sitgreaves, it was necessary to obtain biological data specific to the area. At the request of the author, O'Niel (1981) the Game and Fish Department evaluated the forest and was able to roughly delineate elk ranges as well as offer ways to predict the number of elk the forest could sustain if there were no cattle grazed there.

The two sides of the forest; the Apache and the Sitgreaves (Figure 7.1), are enough different to warrant studying them separately. The Sitgreaves side is considerable easier to analyze. The southern border of the forest runs along the Mogollon Rim, along which are the highest points in the forest. Elk summer in the southern, high

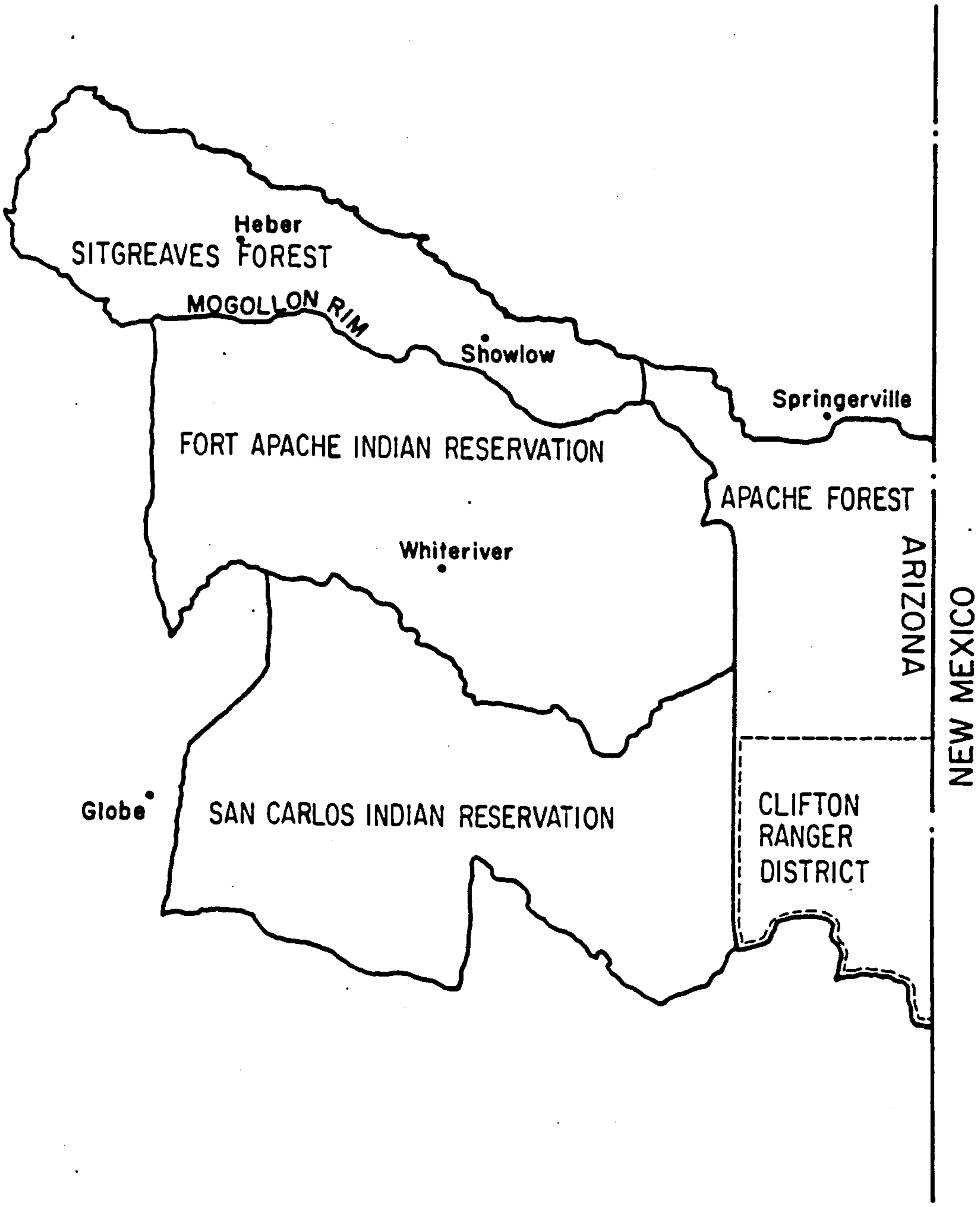

Figure 7.1. Apache-Sitgreaves National Forest.

elevations of the forest and winter in the northern lower areas; staying almost entirely within the forest land.

The Apache side of the forest has a greater variety of mountainous and lowland areas. The winter and summer elk ranges are not as clearly defined as in the Sitgreaves, leaving more room for error. Another difficulty with delineating elk ranges in the Apache is that the elk migrate in and out of the forest, moving into the Fort Apache Indian Reservation and the mountains of New Mexico.

O'Niel posits that optimum elk habitat in the Apache-Sitgreaves could support 15 elk per section. The capacity of the Apache side could be somewhat greater, however, due to the greater amount of rainfall. Using the outlined elk ranges and the estimated 15 elk per section on the most limiting range, one can estimate the number of elk each side of the forest could support in the absence of cattle.

O'Niel also suggests converting the number of cattle present to elk by a biological conversion ratio. Adding that estimate to the number of elk already present yields an alternative estimate of the supportable elk herd. This conversion method works in the opposite direction also; to find the supportable cattle crop in the absence of elk. The assumption here is that the available forage for elk and cattle currently is used to capacity.

The conversion ratio used by O'Niel of Arizona Game and Fish is 2 to 1; 2 elk consuming as much forage as 1 cow. Earlier in this chapter a conversion ratio of 2.5 to 1 was discussed. O'Niel feels the

2 to 1 ratio is fairly accurate for the Apache-Sitgreaves Forest area. It is, therefore, the ratio utilized in this study.

Hanrahan (1981) offered an alternative means to estimate the number of cattle it would be possible to graze if there were no elk in the forest. Hanrahan posited it would be possible to increase all cattle production by 20% except in the Clifton Ranger District where the increase would be 5% at the most. The Clifton District, encompassing the lower half of the Apache side of the forest (Figure 7.1) is not elk country. It is too low in elevation and desert-like in vegetation. O'Niel delineated virtually no elk range in this district, though it was explained that the elk will migrate into the area in very severe winters. The Clifton district is, therefore, excluded from the remaining analysis.

CHAPTER 8

PRODUCTION POSSIBILITIES AND RELATIVE VALUES

A production possibilities frontier shows the greatest possible production given a fixed set of resources. Production at any point along this frontier utilizes available resources fully. $\overline{ab}$ in Figure 8.1 is a hypothetical production possibilities frontier between two products X and Y. From a to c products X and Y relate to each other in a complimentary fashion. More of one product can be obtained while still increasing production of the other product. The d to b range indicates a supplementary region of production in which more of one product can be produced without decreasing production of the other. Both of these situations can occur when one product yields a by product used in the production of the other at some point in the scale of production. From c to d, X and Y substitute in a competitive fashion at an increasing rate. This competitive situation is the region in which the optimum level of production normally occurs.

The relative values of X and Y are mapped in an iso-net-benefit curve $\overline{ef}$. The slope of this curve is mathematically derived as follows:

$$\overline{NB} = NB_X\,(Q_X) + NB_Y\,(Q_Y) \qquad \text{(Eq. 8.1)}$$

$$dNB = \frac{\partial NB}{\partial Q_X}\,\partial Q_X + \frac{\partial NB}{\partial Q_Y}\,\partial Q_Y = 0 \qquad \text{(Eq. 8.2)}$$

$$MNB_X \, DQ_X + MNB_Y \, dQ_Y = 0 \qquad \text{(Eq. 8.3)}$$

$$\frac{dQ_Y}{dQ_X} = \frac{-MNB_X}{MNB_Y} \qquad \text{(Eq. 8.4)}$$

In Equation 8.1 total net benefits equals the net benefit of producing X as a function of the quantity of X produced, plus the net benefit of producing Y as a function of the quantity of Y produced. The first derivative of this function is the slope of the function which simplifies to the relative marginal net benefits of producing X and producing Y indicated in Eq. 8.4.

The optimum allocation of resources between X and Y, occurs where the slope of the iso-net benefit curve equals the slope of the production possibilities frontier, point Z in Figure 8.1.

The slope of the production constraint is derived as follows:

$$\beta Q_X + Q_Y = \alpha \qquad \text{(Eq. 8.5)}$$

$$Q_Y = \alpha - \beta Q_X \qquad \text{(Eq. 8.6)}$$

$$\frac{dQ_Y}{dQ_X} = -\beta \qquad \text{(Eq. 8.7)}$$

The slope, in Equation 8.7, = $-\beta$. The optimum point of production is then:

$$-\beta = \frac{-MNB_X}{MNB_Y}$$

The net benefits of both elk and cattle production in this study are estimated using the principles of consumers' and producers' surplus. The aggregate net benefits are converted to net benefits per

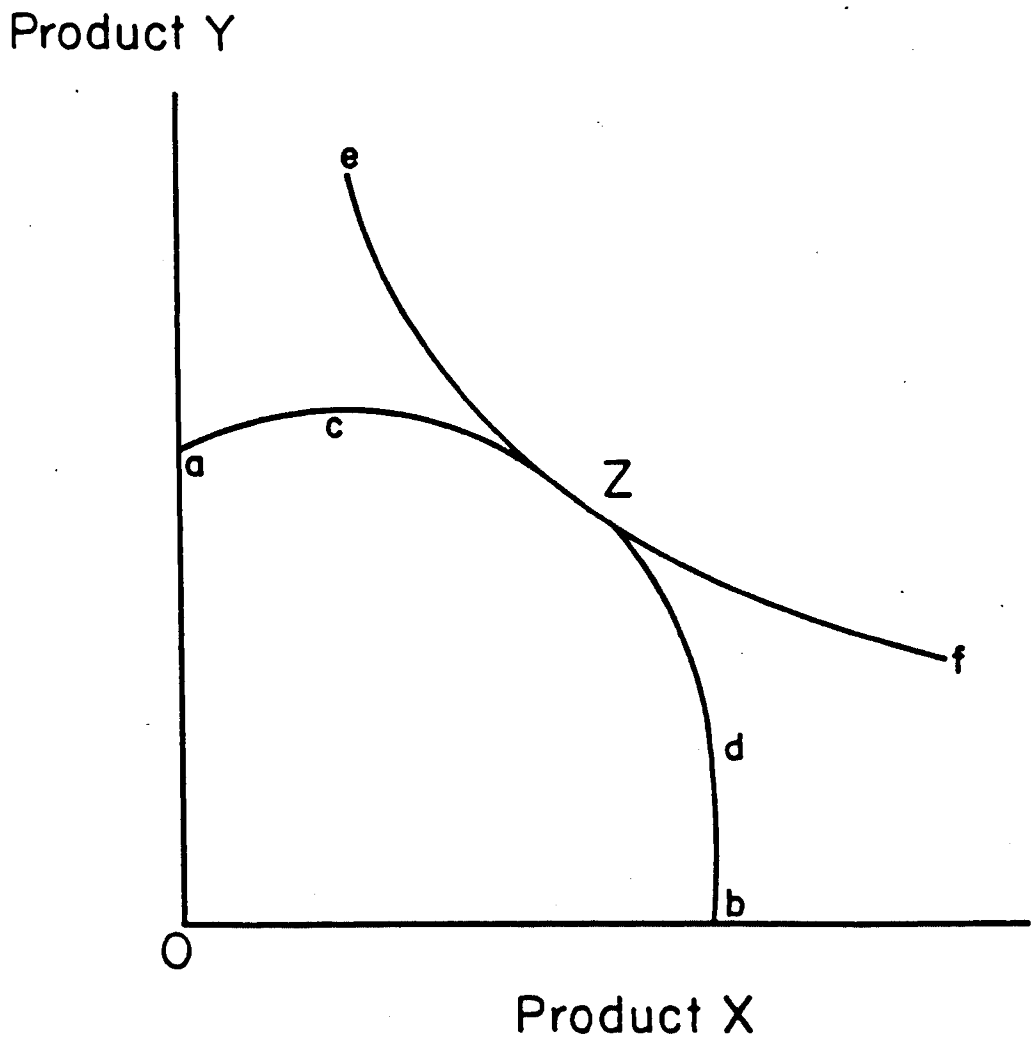

Figure 8.1. Hypothetical production possibilities frontier and iso-net-benefits curve.

animal unit year of forage. The relative net benefits per animal unit year of forage are plotted to form a segment of an iso-net-benefit curve to be compared to estimated product transformation curves.

Production Estimates

A precise production possibilities frontier between cattle and elk would take into consideration trade-offs in all the variables discussed in the previous chapter and possibly many more. A very specific analysis, for instance, could look at the competition on a section by section basis. Such an evaluation is beyond the limited scale of this project.

Four approximate production possibilities are defined, two for both the Apache and Sitgreaves side of the forest. The first method of estimation bases forage capacity on current utilization and a biological conversion ratio of 2 elk to 1 cow as explained in Chapter 7.

The second method estimates maximum elk and cattle production independently. The maximum elk herd is projected using a posited 15 elk per section of optimum elk habitat as estimated by O'Niel (1981) of the Arizona Game and Fish Department. O'Niel delineated the summer and winter elk ranges in the two Forests. Since elk migrate with the seasons, optimum elk habitat will vary with the seasons. A resource can only support as many animals as its most limiting range can support. Therefore, one can consider the most limiting range, winter or summer, in each forest to be optimum elk habitat. The 15 elk per section are multiplied times the number of sections in thelimiting range to arrive at an estimated carrying capacity. The independent estimate of a maximum cattle herd is calculated using a proposed twenty percent greater capacity without elk as suggested by Hanrahan (1981) of the U.S. Forest Service in Springerville.

Tables 8.1 list the production estimates. For maximum cattle production they are fairly close under both methods of estimation, 3,902 AUY vs. 4,117 AUY on the Sitgreaves and 9,957 AUY vs. 9,911 AUY on the Apache. The estimates for maximum elk production are very close on the Sitgreaves, 3,902 AUY vs. 3,930 AUY. However, there is a large discrepancy between the two estimates of elk production possible on the Apache, 9,057 AUY vs. 4,462. An explanation could lie in the fact that the elk ranges within the Apache forest were so difficult to delineate. Or, the carrying capacity could be greater than 15 elk per section.

The estimates listed in Tables 8.1 and 8.2 are calculated in terms of an animal unit year (AUY) of forage. This unit is the amount of forage it takes to support one animal unit for one year. One adult cow is assumed to be one animal unit. Approximately two elk eat as much as one cow; or, two adult elk equal one animal unit and consume one AUY of forage. The AUY of forage for elk, therefore, represent half the actual number of elk to be grazed. The number of cattle and elk are converted to AUY forage utilization because it is convenient to calculate the value of an AUY of forage for each use. Production possibilities are plotted in Figures 8.2-8.5.

Table 8.1. Current and possible levels of forage utilization by elk and cattle in the Apache-Sitgreaves National Forest.

	Elk		Cattle	
	Sitgreaves Side of Forest	Apache Side of Forest[a)]	Sitgreaves Side of Forest	Apache Side of Forest[a)]
	AUYs of Forage Utilization			
Actual use 1978	471	798	3,431	8,259
Estimated maximum use by method one[b)]	3,902	9,057	3,902	9,057
Estimated maximum use by method two[c)]	3,930	4,462	4,117	9,911

a) Excludes Clifton Ranger District.

b) Maximum forage utilization by one species in the absence of the other, using a 2 to 1 conversion ratio and actual levels of use.

c) Independent estimates of forage utilization by one species in the absence of the other. Elk estimate: Assumes optimum elk habitat delineated by O'Niel could support 15 elk per section. Cattle estimate: Assumes cattle allotments could be increased by 20% as predicted by Hanrahan.

Table 8.2. Summary of values for cattle and elk production.

Source of Value	Forage for Cattle	Forage for Elk
	Dollars per AUY of Forage	
Consumers		
on a national scale	405.47	(a)
on a state scale	3.33	348.07
Producers		
those who loose	62.57	(b)
those who gain	.61	
Net Social Value		
on a national scale	467.43	
on a state scale	65.29	348.07

a) The value of an AUY of forage for elk is determined only on a state scale.

b) Since elk are public goods, there is no producers' surplus.

Value Estimates

Table 8.2 summarizes the values of an AUY of forage for grazing cattle and elk as determined in Chapter 4 and 6. There are two values of cattle grazing. One is where consumers and producers of beef across the United States are assumed to have an interest in, or value, the Apache-Sitgreaves cattle crop. This value is probably most reasonable because the market for beef is nationwide. Thus, any change in production will have national ramifications.

The other value of cattle assumes that only consumers and producers of beef within the State of Arizona value the Apache-Sitgreaves cattle crop. It can be argued that it is the correct measure of value, because it is more comparable to the value found for elk production since the value of elk production is based only on Arizona. It is true that almost all the participants in the value of elk hunting study were from Arizona. It is also true that some people across the nation and even throughout the world place a value on the same elk for different reasons. However, it is beyond the scope of this project to determine what that extended value of elk might be.

The relative net benefits of cattle and elk production are graphed in Figures 8.2-8.5. Line segment ab, in each figure, is an estimate of the benefits of elk production relative to the benefits of cattle production from a national perspective. Line segment cd, in each figure, is an estimate of these relative benefits from a state perspective.

The estimated iso-net-benefit curves in Figures 8.2-8.5 are linear since they were derived from only two data points, the benefits

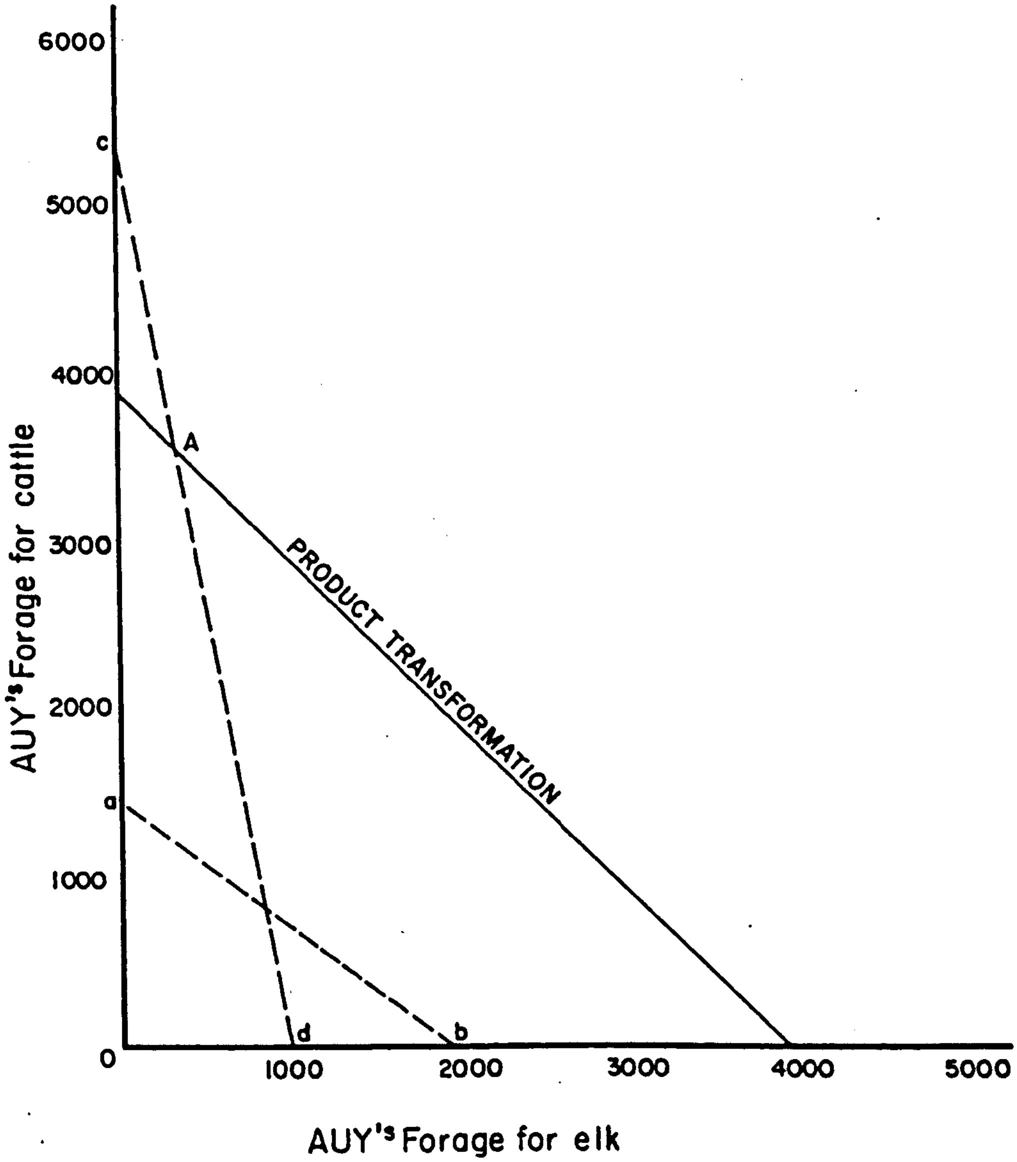

Figure 8.2. Product transformation and relative values on the Sitgreaves Forest using method one.

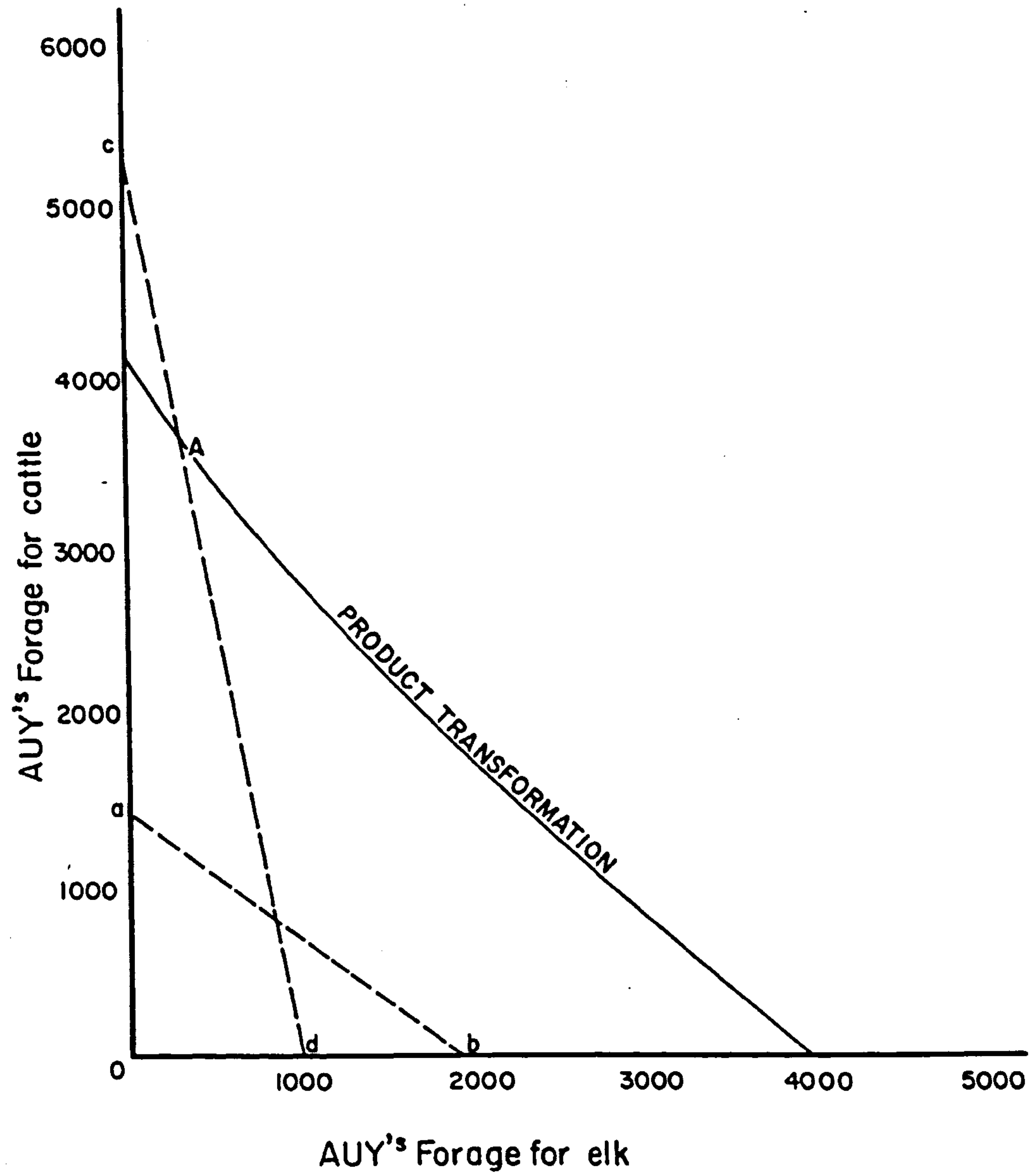

Figure 8.3. Product transformation and relative values on the Sitgreaves Forest using method two.

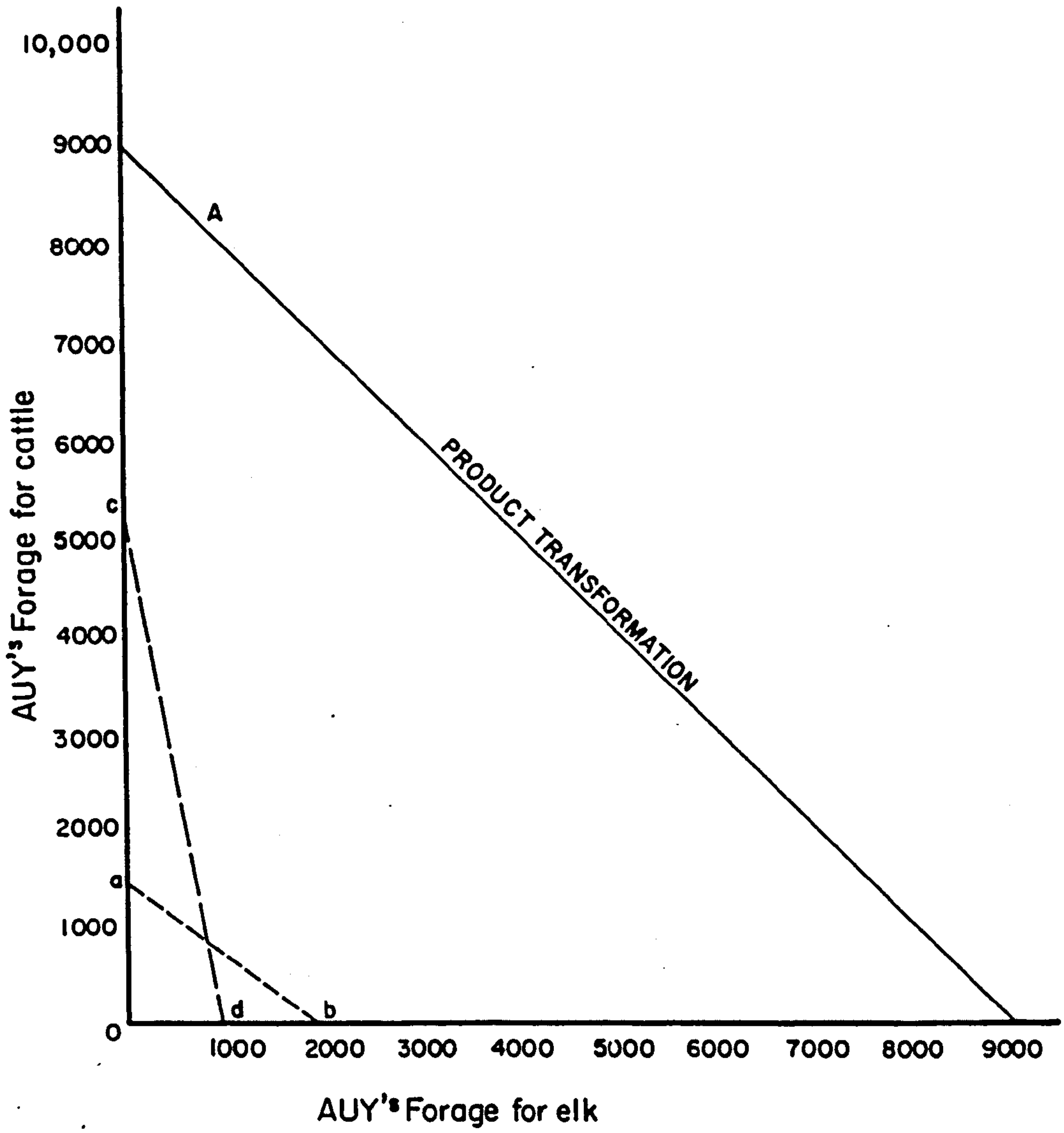

Figure 8.4. Product transformation and relative values on the Apache Forest using method one.

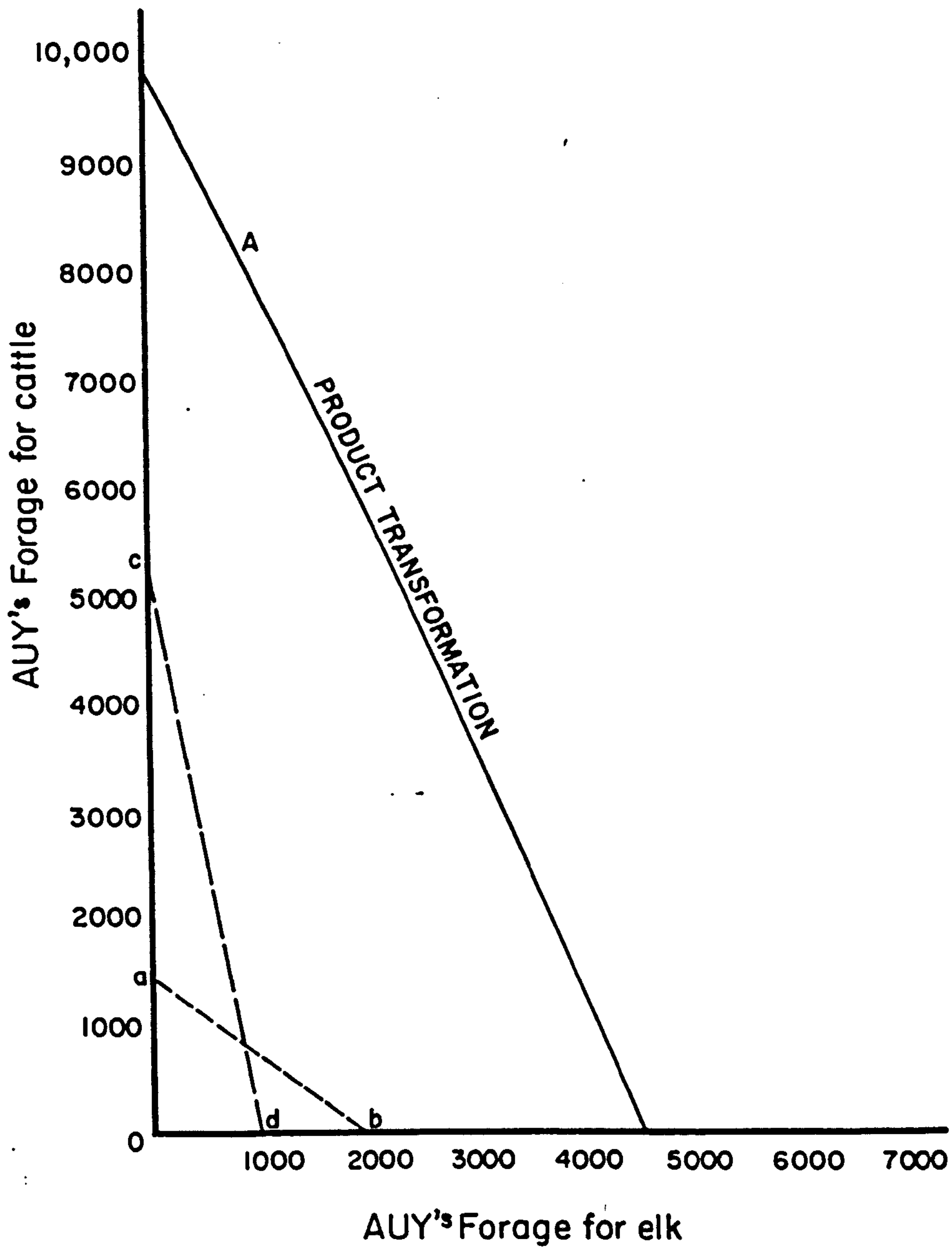

Figure 8.5. Product transformation and relative values on the Apache Forest using method two.

of all cattle and no elk versus the benefits ofall elk and no cattle. These curves are not true marginal net benefit curves since the marginal trade-offs between cattle and elk were not measured. However, the slope of the curves would be the same as the true curves near the actual point of production.

Optimality

It is assumed that available forage is utilized to capacity. Therefore, the 1978 level of production lies on the production possibilities frontier. This level is indicated as point (A) on all the product transformation curves derived.

In method one the 1978 levels of utilization are converted by the 2 to 1 ratio to determine the maximum levels of elk and cattle production. Because this method is simply a mathematical conversion based on actual levels of utilization, the resulting product transformation curves (Figures 8.2 and 8.4) are straight lines.

Linear product transformation curves can exist but they are rare and only occur when (a) the same physical resources are required for both products at the same time of the year, (b) the products are produced at identical times of the year, and (c) neither product produces a by-product used in the production of the competitor (Heady, 1952).

When combining a linear product transformation function with a linear-iso-net-benefit line, the optimum level of production is one product or the other entirely. However, it is known that elk and cattle compete for available forage, even in a complementary way over certain production levels; and that in the competitive stage the relationship is unlikely to be perfectly linear. One can, therefore, assume that the true production possibilities curve between cattle and elk is concave to the origin over some range. Further, it is reasonable to submit that the straight line product transformation lines derived in this analysis lie very close to the true curves at least near the point of current usage.

Under the assumption that the curves are really concave and lying very close to the linear functions sketched in Figures 8.2 and 8.4, some important conclusions can be drawn. If the national value of cattle grazing is considered, the iso-net-benefit is $\overline{ab}$. The optimum point of production would lie somewhere near the top of the product transformation curve, very possibly near the 1978 level of production, in both the Apache and Sitgreaves Forests.

If the state value of cattle grazing is considered, $\overline{cd}$ depicts the relative values. The point of optimum production is in the lower half of the production possibilities frontier calling for a shift in production from cattle to elk.

In method two, maximum levels of production are calculated independently of the actual levels of production and each other. Figure 8.3 depicts the relationship found by this method on the Sitgreaves side of the forest. The product transformation curve is convex to the origin which, like the linear functions found using method one, indicates the optimum level of production is one product or the other solely.

A convex curve is not credible theoretically in this case. Though product transformation functions of this form are found in agriculture, they normally occur in very small operations where economies of scale are never reached and both products are yielding increasing returns. It is known that most cattle ranchers in the area operate under conditions of decreasing returns. (See discussion, Chapter 6, Producer's Surplus). Therefore, it is unlikely this curve depicts the true situation.

Figure 8.5 shows a product transformation curve derived with method two, for the Apache side of the forest. It is very slightly concave to the origin. The curve is so slight, however, that the optimum points of production still turn out to be one product or the other.

Since the conversions of method two led to such an unlikely curve for the Sitgreaves, little confidence is placed in them by the author. There is also the discrepancy of estimates on the Apache as discussed above. Therefore, Figures 8.3 and 8.5 are both dismissed as unlikely.

CHAPTER 9

CONCLUSION

The first task of this study was to value the recreational experience of elk hunting in the Apache-Sitgreaves National Forest. The three methods of non-market valuation suggested by the Water Resources Council, the unit day value (UDV) approach, the travel cost method (TCM) and willingness to pay (WTP) were each utilized. The TCM of valuation posed the greatest problems. It is felt the problems occurred because of the unique circumstances of the elk hunt. The law restricts a hunter to hunt once every three years, if he (she) is lucky, and within a set time period of 6-8 days. The hunter may, therefore, be willing to pay much more than his (her) travel expenses to experience the elk hunt. Thus, the net social benefit value obtained with the TCM ($223,950) is considered an underestimate.

When asked their willingness to pay directly, in the WTP method of valuation, hunters indicated a greater value of the elk hunt ($441,700). This estimate was used in the final analysis because it had greater statistical significance than the travel cost estimate, and generally appeared most credible to the author.

The UDV approach to valuation yielded a value very close to the one obtained under WTP. However, it was dismissed as the less credible result because of its lack of a theoretical basis. The conclusion is that the WTP approach to recreation valuation, or some derivative thereof, is the best method for valuing a recreational experience like elk hunting in Arizona.

The value of cattle grazing on the same resource base is relatively easy to estimate because cattle are sold and thus valued in the market place. Net social benefit as a function of both consumers' and producers' surplus was the value estimated so as to compare the values of cattle and elk production.

Two values of cattle were used in the final analysis. One was calculated from a national perspective and the other from a state perspective. In the final analysis, the relative values of cattle and elk grazing, in the form of a iso-net-benefit line, are combined with a production possibilities frontier to obtain an optimum range of production. The national perspective of cattle value relative to elk value suggests a combination of elk and cattle grazing which favors cattle; possibly the current allocation of forage is optimum. Analysis with the state perspective suggests a shift toward elk in forage allocation.

The greatest challenge of this project was to develop a production possibilities frontier between cattle and elk in the Apache-Sitgreaves National Forest. Product transformation curves were estimated; but, much more extensive research will be required to obtain a full understanding of these biological relationships. It is hoped that this research will provide a base for further research toward estimation of the optimum combination of products on our multiple product forest areas.

APPENDIX A

THE VALUE OF ELK HUNTING GIVEN

A HYPOTHETICAL SITUATION

In the last section of the questionnaire interviewees were asked their willingness to pay for an elk hunting permit in an "as is" situation, as well as their willingness to pay given a hypothetical situation in which hunters are guaranteed a success ratio 33% higher.

The second question was:

In 1979 in hunt 301, 34 hunters out of every 100 hunters killed an elk. In hunt 303 the count was 13 out of every 100. In hunt 351 the count was 6 out of every 100. If you were certain that the success rates for your hunt number would be 1/3 higher than in 1979, that is 45 out of 100 for hunt 301, 17 out of 100 for hunt 303, and 8 out of 100 for hunt 351, what is the maximum amount you would be willing to pay for your elk hunting permit in order to participate in the same hunt as you did in 1979? (Circle one).

$25 $30 $35 $40 $45 $50 $55 $60 $65 Greater $_____ specify.

Analysis for this question is done exactly the way it was for the original willingness to pay question. Demand curves are derived from cumulative frequencies for each hunt separately. The resulting values are then summed.

The three functions obtained are:

Hunt 301: $Y = 1{,}668.70X^{-.8} - 24.99$

$R^2 = .978$

Hunt 303: $Y = 2{,}030.48\ X^{-.9} - 14.26$

$R^2 = .936$

Hunt 351: $Y = 4{,}667.40\ X^{-1.15} - 8.05$

$R^2 = .929$

Y = demand for permits in cumulative frequencies.

X = the respondents maximum willingness to pay.

The cumulative frequencies of each demand curve are transformed into the actual number of applicants to find the net social benefits and consumers' surplus. Each function is integrated between 0 and 100 percent, that is, between 0 and the total number of applicants, to find net social benefits. Total permit costs are subtracted to find consumers' surplus. Net social benefits and consumers' surpluses for the three hunts are summed to obtain estimated total net social benefit and consumers' surplus of the site as used for the elk hunting activity. All values are listed in Table A.1.

The total annual net social benefit determined in the "as is" situation is $441,700, only $16,612 less than the value obtained here. The total annual net social benefit is not much larger in the hypothetical situation even though the hunters are offered a substantial increase in the success ratio. The values obtained in hunt 301 are actually lower here than in the original situation. This lower value could be due, in part, to statistical error. However, many respondents actually lowered their willingness to pay for a permit when presented with the situation where they are guaranteed a higher success ratio.

Table A.1. The value of elk hunting in the Apache-Sitgreaves area using the willingness to pay method, given a hypothetical situation.

	Net Social Benefits	Consumers' Surplus
Hunt 301	$242,723	$146,723
Hunt 303	190,427	108,627
Hunt 351	25,162	15,162
Total	$458,312	$270,512

LITERATURE CITED

Archer, T. "Performance of Cattle in Arizona Feedlots, by Source of Feeder." Report No. 15, Department of Agricultural Economics, College of Agriculture, The University of Arizona, Tucson. Oct. 1976.

Arizona Game and Fish Department. Arizona Hunting Regulations: Fall 1979-Spring 1980. Phoenix, 1979.

Arizona Game and Fish Department. Wildlife Views. Jan.-Feb., 1970, 19-21.

Bahre, S. Editor. Atlas of Arizona. Yuma: Arizona Information Press, 1976.

Bohm, P. "Estimating Willingness to Pay: Why and How?" Scandinavian Journal of Economics. 1979.

Brown, W. G. and F. Nawas. "Effect of Aggregation Upon the Evaluation and Specification of Outdoor Recreation Demand Functions." Proceedings of the Forty-Fifth Annual Meeting of the Western Agricultural Economics Association. pp. 344-50. Logan, UT., 1972.

Brown, W. G. and F. Nawas. "Impact of Aggregation on the Estimation of Outdoor Recreation Demand Functions." American Journal of Agricultural Economics. 55 (1973): 246-49.

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

Clawson, M. and J. L. Knetsch. Economics of Outdoor Recreation, Baltimore: John Hopkins Press, 1966.

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

Currie, J. M., J. A. Murphy and A. Schmitz. "The Concept of Economic Surplus and Its Use in Economic Analysis." The Economic Journal. 81 December 1971, 741-799.

Dillman, D. A. Mail and Telephone Surveys, New York: John Wiley and Sons, 1978.

Dupuit, J. "On the Measurement of the Utility of Public Works". Annales des Ponts et Chaussees. Second Series, Vol. 8, 1844; Translation Reprinted in D'Munby, Transport, 1968.

Dwyer, J. F., J. R. Kelly and M. D. Bowes. Improved Procedures for Valuation of the Contribution of Recreation to National Economic Development. University of Illinois, Urbana-Champaign. September, 1977.

Federal Land Policy and Management Act of 1976. PL 94-579, (S.507), October 12, 1976.

Flook, Donald R. A Study of Sex Differential in the Survival of Wapiti. Canadian Wildlife Service, Report Series-No. 11. Ottawa, Canada: The Queen's Printer for Canada, 1970.

Gum, R. L. and W. E. Martin. "Problems and Solutions in Estimating the Demand for and Value of Rural Outdoor Recreation." American Journal of Agricultural Economics. 57 (1975): 559-566.

Hanrahan, M. P. Personal communication throughout research. Range and Wildlife Staff member, The U.S. Forest Service, Springerville, Arizona.

Heady, E. O. Economics of Agricultural Production and Resource Use, Englewood Cliffs, N.J.: Prentice-Hall Inc., 1952.

Hicks, J. R. "The Four Consumer's Surpluses." Review of Economic Studies. 11(1943): 31-41.

Hotelling, H. "The Economics of Public Recreation." The Prewitt Report. Mimeographed. Washington: Lond and Recreation Planning Division, National Park Service, 1949.

Langford, W. A. and D. J. Cocheba. The Wildlife Valuation Problem: A Critical Review of Economic Approaches. Canadian Wildlife Service Occasional Paper No. 37, 1978.

Marshall, A. Principles of Economics. Eighth edition, London, 1936.

Martin, W. E. "Migiating" The Economic Impacts of Agency Programs for Public Rangelands. Workshop on Applying Socio-Economic Techniques to Range Management Decision Making. Boise, Idaho, 1981.

Martin, W. E. and G. L. Jefferies. "Relating Ranch Prices and Grazing Permit Values to Ranch Productivity." Journal of Farm Economics. 48: 233-242, May, 1966.

Martin, W. E. and G. B. Snider. "The Value of Forage for Grazing Cattle in the Salt-Verde Basin of Arizona." Report No. 22, Department of Agricultural Economics, College of Agriculture, The University of Arizona, Tucson, April 1980.

Martin, W. E., J. C. Tinney and R. L. Gum. "A Welfare Economic Analysis of the Potential Competition Between Hunting and Cattle Ranching." Western Journal of Agricultural Economics. 3: 87-98, December 1978.

Murie, O. J. The Elk of North America. Harrisburg, Pa.: The Stackpole Company, 1951.

O'Niel, J. Personal communication, spring and summer 1981. Region I Game Specialist, The Arizona Game and Fish Department, Pinetop, Arizona.

Rand McNally Premier World Atlas. Chicago, New York, San Francisco: Rand McNally Company, 1978.

Randall, A. "Evaluating Non-Market Goods and Services: Some Conceptual Considerations." Staff Paper 51, Department of Agricultural Economics, University of Kentucky, Lexington. July 1977.

Schmidt, J. L. and D. L. Gilbert, editors. Big Game of North America. Wildlife Management Institute Book. Harrisburg, Pa.: Stackpole Books, 1978.

Smith, A. H. and W. E. Martin. "Socioeconomic Behavior of Cattle Ranchers, with Implications for Rural Community Development in the West." American Journal of Agricultural Economics 54(1972): 217-225.

Sublette, W. J. and W. E. Martin. Outdoor Recreation in the Salt-Verde Basin of Central Arizona: Demand and Value. Technical Bulletin No. 218, University of Arizona, Tucson. 1975.

Tinney, J. C. "Comparative Estimates of Market and Non-Market Values for Products of a Given Land Base." Unpublished M.S. Thesis, Department of Agricultural Economics, University of Arizona, Tucson. 1977.

Trippensee, R. E. Wildlife Management, Upland Game and General Principles. New York: McGraw Hill Book Company, 1948.

U.S. Department of Agriculture. Agricultural Statistics 1979. U.S. Government Printing Office, Washington, D.C., 1979.

U.S. Department of Agriculture. Arizona Agricultural Statistics 1979. Compiled by the Arizona Crop and Livestock Reporting Service, College of Agriculture, University of Arizona, Phoenix. 1979.

U.S. Department of Agriculture, Forest Service. Economic Analysis of Allotment Management Plans and Range Improvements. WO-Range Review Draft. FSH 2209.11 p.88, 1980.

U.S. Department of Agriculture, Forest Service. "National Forest System Land and Resources Management Planning." Federal Register 44 (181) (1979): 53928-59999.

U.S. Department of Agriculture, Forest Service. Wildlife Habitats in Managed Forests, the Blue Mountains of Oregon and Washington. Agricultural Handbook No. 553. Washington, D.C., September 1979.

U.S. Department of Agriculture. Map of the Apache-Sitgreaves National Forest of Arizona and New Mexico. Compiled Regional Office, Albuquerque, N.M. Washington D.C., 1977.

U.S. Department of Agriculture and The University of Arizona. Western Livestock Round-Up. University of Arizona, Tucson, February 1979.

U.S. Department of Agriculture and The University of Arizona. Western Livestock Round-Up. University of Arizona, Tucson, February 1980.

U.S. Water Resources Council. "Procedures for Evaluation of National Economic Development Benefits and Costs in Water Resources Planning." Federal Register. Vol. 44, Part II, No. 102, May 24, 1979.

Willig, R. D. "Consumer's Surplus Without Apology." The American Economic Review, 66 (1976): 589-597.

U.S. Department of Agriculture, Forest Service. "National Forest System Land and Resource Management Planning." Federal Register 44 (181) (1979): 53928-53999.

U.S. Department of Agriculture, Forest Service. Wildlife Habitats in Managed Forests, the Blue Mountains of Oregon and Washington. Agricultural Handbook No. 553. Washington, D.C., September 1979.

U.S. Department of Agriculture. Map of the Apache-Sitgreaves National Forests of Arizona and New Mexico. Southwest Regional Office, Albuquerque, N.M. Washington, D.C., 1977.

U.S. Department of Agriculture and The University of Arizona. Western Livestock Round-Up. University of Arizona, Tucson, February 1979.

U.S. Department of Agriculture and The University of Arizona. Western Livestock Round-Up. University of Arizona, Tucson, February 1980.

U.S. Water Resources Council. "Procedures for Evaluation of National Economic Development Benefits and Costs in Water Resources Planning." Federal Register. Vol. 44, Part II, No. 242, Dec 14, 1979.

Willig, R. D. "Consumer's Surplus Without Apology." The American Economic Review. 66 (1976): 589-597.