AN ABSTRACT OF THE THESIS OF

Melissa N. Unruh for the degree of Master of Science in Agricultural and Resource Economics presented on May 2, 1983

Title: An Analysis of Stated Preferences for Marginal Water Allocation in the Western United States

Abstract approved: Redacted for privacy

Russell L. Gum

This analysis utilized data from, "A Survey of the Public's Attitudes Toward Soil, Water, and Renewable Conservation Policy," to develop a framework that policy makers may use in multi-objective programs. Specifically, a utility maximization framework defining a functional relationship between stimuli (a defined policy allocation of water to different uses) and the resultant level of satisfaction or utility was posited. Appealing to work in the psychophysical field, a Cobb-Douglas-type (power) function, which (according to psychophysists) conforms to the Weber-Fechner law (i.e., that equal ratios of physical stimulus correspond to equal perceptual ratios of subjective sensation), was used to define a relationship between water allocated according to some policy and satisfaction received.

The implications of using a Cobb-Douglas-type function are (1) constant elasticity of utility or satisfaction is exhibited, and (2) diminishing marginal satisfaction is exhibited. Additionally, this analysis took advantage of the fact that for a case

where the units of the budget equal the units of the commodity (i.e., a respondent's budget was in gallons of water), the implicit price of each commodity equals 1.0. Utilizing the constant, k, in the equation, as a "welfare weight" would enable groups of individuals to be ranked, according to policy makers' criteria. This analysis assumed an equal welfare weighting (k = 1.0) for all individuals. However, this assumption does not exclude the possibility of using this type of analysis if some other welfare weighting is desired.

An Analysis of Stated Preferences For

Marginal Water Allocation In The

Western United States

by

Melissa N. Unruh

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed May 2, 1983

Commencement June 1984

APPROVED:

Redacted for privacy

Professor of Agricultural and Resource Economics in charge of major

Redacted for privacy

Head of Department of Agricultural and Resource Economics

Redacted for privacy

Dean of Graduate School

Date Thesis is presented May 2, 1983

Typed by and for Melissa N. Unruh

ACKNOWLEDGEMENTS

After being around for too long, it's time to give thanks to those who have helped see me through the program.

My first thanks goes to my parents. Although they (and probably many others) still wonder what a natural resource economist actually does, they have given much support.

Much thanks to Russ Gum, my major professor, who tried to keep me in line and, at least part of the time succeeded. His financial assistance and help with the thesis project were invaluable; body and soul stayed together and a bunch of "stuff" was transformed into something readable. Both Jack Edwards and Steve Buccola have given much time, providing many suggestions that helped bring the paper into sharper focus. Their help has been greatly appreciated.

Thanks to Jane Tuor, who did all the typing corrections for the final copy of the paper. I would have been up all night with it.

I give my very special thanks and gratitude to my near-future husband, almost-Dr. Jim Wilson. His editing and proofreading of all drafts of this paper and his artwork for figures were an immense help and greatly appreciated. But most of all, his unending support and understanding throughout this past year have been immeasurable; to keep a procrastinator like me going and to do it in good cheer (except when he's being a Bear) is a real feat. No matter when I had to work - no matter if things were going horribly or great - he was always right there; which is one reason why I'm marrying him.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

AN ANALYSIS OF STATED PREFERENCES FOR MARGINAL WATER ALLOCATION IN THE WESTERN UNITED STATES

CHAPTER I

CONSUMER PREFERENCE ANALYSIS

Introduction

The general public has often perceived water as a resource much different in nature than other natural resources. There has existed a "peculiar, metaphysical line of reasoning which seems to pervade public thinking about water; the 'water-is-different' or the 'magic-of-water' philosophy"[Hirshliefer, p. 367, 1960]. Such philosophy has led individuals to imagine water as a free good, where the cost to users should not be more than net cost of production and delivery [Kelso, 1967]. The "magic-of-water" philosophy has also led to other images of water, as described by Kelso [1967], which were (1) the survival image; (2) the image of irrigation fundamentalism, where agriculture has been perceived as the basis of any society; (3) the desert image, where water has been viewed as truly scarce, implying more must be placed there for a society to be a viable economic unit; (4) the idyllic idol image, where water has been deemed necessary for enhancement of the environment; and (5) the recreation image, where man has felt water must be present for his enjoyment and for future generation's enjoyment.

Historical and current water laws and water development patterns have reflected such images of water. For example, the appropriations doctrine has dominated western U.S. water rights laws. The doctrine insures that individuals have the right to water access, although they may not live near the water source. When the West was being settled, wars between landowners often occurred over allocation of water. The underlying reasons for the disagreements which occurred then and which still occur have probably been due to the images people have held for water. In the West and in the U.S., as a whole, there has existed within society a feeling that every individual was entitled to water for whatever use he/she wished. Because every individual may not have been able to pay the market price for water and thus, would be excluded from consuming it (which would be against the "public good" image), the government began to supervise water allocations. Consequently, water allocation has been insulated from pressures of competitive markets that individual preferences and demands would have otherwise altered [Kelso, 1967]. Because water programs and projects have been divorced from market activities, it has been argued that water allocations were economically inefficient and active competitive markets should have been allowed to correct inefficiencies [Eckstein, 1958; Kelso, 1967]. However, since water has been and probably will continue to be a nonmarket good allocated under governmental auspices, improvement of the current allocation system is perhaps a more appropriate problem to consider.

By law, governmental agencies must obtain public input for development of water programs and policies (in addition to other natural resource programs). Since, "the public from this point on, is going to intrude in public decisions" [Doerksen and Pierce, p. 6, 1976], it would seem appropriate to use that input in such a way that would better the present system.

Problem Statement and Objectives

The Soil and Water Resource Conservation Act (RCA) of 1977, P.L. 95-192, directed the Secretary of Agriculture to examine and evaluate the status, conditions, and trends in soil, water, and related resources in the United States [USDA Part I, 1981]. In response to this mandate, the Soil Conservation Service (SCS) of the United States Department of Agriculture (USDA) contracted Louis Harris and Associates, Inc. to conduct a nationwide survey entitled, "A Survey of the Public's Attitudes Toward Soil, Water, and Renewable Resources Conservation Policy" (RCA Survey), as part of public participation activities undertaken to help design and develop future USDA conservation[1] programs [USDA, 1980]. Accordingly, the major purposes of the survey were (1) to assess the public's level of understanding of soil and water conservation programs and problems; (2) to determine the level at which the public believes in the conservation ethic; (3) to estimate the public's preferences with respect to the allocation of land, water, and financial resources among competitive uses and among alternative soil and water conservation programs; (4) to examine public attitudes toward alternative options for increasing domestic

1/ Conservation, by definition, is "the official care and protection of natural resources, as forests" [Guralnik, Ed., p. 302, 1978]. The USDA is entrusted with the design of soil and water conservation programs in this country. Hence, they must develop conservation programs to manage those resources, where conservation is defined in the strictest sense.

energy supplies; (5) to assess public perceptions of the structure of agriculture in the U.S.; and (6) to examine public views on the citizen participation process in Federal government decision making [USDA, 1980].

The findings from this survey were released by M. Rupert Cutler, then Assistant Secretary of Agriculture for Natural Resources and Environment, on January 17, 1980. To date, the information obtained has had little effect on USDA decision making and planning processes. In spite of amassing four volumes of data from the RCA Survey, only a one page summary of those results can be found in the subsequent RCA report [USDA Part I, p. 317, 1981]. If the survey results are to be more useful to the USDA, in general, and specifically to the SCS in development of multi-objective conservation programs, a more meaningful presentation and analysis of the public's revealed preferences is warrented.

The most democratic method of making public policy, according to Edwards and Sharkansky, [1978], is for policy makers to follow public preferences. This method requires, first, the public in question to have opinions and preferences not molded by policy makers and second, for those preferences to be discernable to policy makers. Third; the method requires policy makers to actually follow public opinion.[2]

Considering the above requirements, there may be little

2/ Some have argued that governmental agencies and institutions have no desire to determine preferences of the general public; that bureaucrats respond only to elite groups, and make their decisions behind closed doors [Downs, 1967; Mazmanian, 1976; Mazmanian and Nienaber, 1976].

justification for invalidating a public opinion survey on the basis that individuals interviewed did not have perfectly formed preferences. In theoretical treatments of consumer behavior, individuals are generally assumed to act rationally, where rationality is defined within the bounds of specific assumptions about preference orderings for bundles of goods. Such assumptions about consumers lead to the conclusion that individuals will state their preferences in a manner that reveals their highest possible (given constraints) level of satisfaction at that point in time. However, economic theory implies little about the underlying forces that result in optimal choice. Theory implies that an individual's behavior generally would follow theoretical predictions under given assumptions. Therefore, it does not matter how or by whom their opinions were formed (contrary to Edwards and Sharkansky's [1978] first requirement). Such subjectivity is within all individual preferences and daily decisions, and does not necessarily inhibit decision making processes. It is that subjectivity, in fact, which the analyst seeks to measure, while interjecting as little bias as possible. Because individual subjectivity is an inherent part of reality, of which policy makers are faced with when defining policy, the use of public opinion surveys as a data source may be the most appropriate information base for policy makers, when dealing with non-technical issues.[3]

If Edwards and Sharkansky's [1978] second requirement is

3/ Decision theory analysts generally advocate the use of expert panels for policy making processes of a technical nature [Kenny and Raiffa, 1976; Gum, 1982].

interpreted in a manner where "discernable public preferences" implies discernibility of individual preferences, then the requirement is a moot point, theoretically. It is generally assumed individual preferences are unique representation of that individual's level of satisfaction at that point in time. A person's attainment of a given level of satisfaction or utility is a reflection of his/her personal tangible and intangible attributes. As a result, the problem may not be one of indiscernable preferences, but rather of preferences being so discernible and varied that policy makers may have difficulty interpreting their meaning.

However, if "discernable public preferences" in the second requirement, refers to discernability of preferences among groups in the public sector, the requirement becomes more relevant. If several different policy options were presented to the public, in a manner that would allow them to rank each option, then grouping data and rank ordering of policy options by preferences could be accomplished. Such methods of "discernment" are important for profitable use of questionnaire data. However, it should be noted that proper construction of a questionnaire is important if grouped data is desired.

While the third requirement set out by Edwards and Sharkansky certainly appears to be a crucial element in the use of public opinion surveys, it lies beyond the focus of this discussion. It is within a researcher's realm to analyze and interpret data and to then present the results and alternative options in an unbiased a manner as possible. Afterwards, it is policy makers who evaluate public opinion in making judicious decisions. Since a policy maker's job is to evaluate options and predict consequences of alternatives pertaining to a given policy, he/she should have all relevant information that would enable such evaluation to occur. Although, the analyst/researcher is not part of decision processes, he/she can try to present clear information that may facilitate such policy making.

The purpose of this research is to present information from a public opinion survey in a framework, which will allow policy makers to make decisions with greater ease. A policy framework for public preferences toward marginal water allocation in the western United States, stated in the RCA Survey (described earlier), will be presented. The data are obtained from one question[4] in the RCA Survey, with a sample size of 1,527 individuals, obtained from eleven western states. The data analysis will be developed through use of consumer behavior theory.

4/ Question #17. "Here is a board which shows a number of uses for which water is in great demand. Now let's assume that there was enough water to meet the minimum needs for each of these uses. From each additional 100 gallons of water available, how would you divide up those gallons among the different uses? Suppose each of these cards stands for 5 gallons of water - 100 gallons altogether. Just divvy up the cards among the boxes shown on this board to show how you think these additional 100 gallons of water should be used. The competing uses are:

(1) water for household use,
(2) water for industry and jobs,
(3) water for producing food,
(4) water which fish and wildlife need to live, and
(5) water for developing energy resources"

[USDA, p. 12, 1980].

Summary

In recent years, public (individuals and groups) input has begun to play a larger part in political decision making processes than it had previously. Such change has been partially due to public laws and governmental agencies that require such input be considered in policy analyses. Hence, the present research will specifically analyze public preferences toward water allocation in the western United States, based on data from the RCA Survey. The information was obtained for the USDA, who feels that due to population growth, industrial development, and changing water use priorities, which have been placing new demands on water in western states; "There is a need for interdisciplinary research and extension activities to evaluate competing demand for water in the West ..." [USDA Part II, p. 20, 1980]. In response to the perceived need from the USDA, the RCA Survey data will be used to set up a framework, which may allow policy makers to better evaluate competing water demands in the West.

After a review of literature dealing with individual preferences and their associated measurements of satisfaction in Chapter II, Chapter III will contain a discussion of consumer behavior theory, which is the basis of this research's policy framework. Chapter IV will form the methodology for the consumer preference analysis, including a more complete description of the data and a presentation of the methodological technique. The results and conclusions of the analysis will then be presented in Chapter V, along with a discussion of the data and methodology. A brief discussion of future research needs will also be included.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Increased public awareness toward policy issues and specifically toward natural resource conservation issues has been an impetus for increased study of individual perceptions and attitudes. The underpinnings of such study lie in the basic precepts of utility and demand theory. This chapter will discuss some of the literature covering those basic precepts. In addition, literature which examines methods of estimating utility functions will be presented, as well as literature specifically relating to analysis of survey data.

Basic Precepts in Utility Theory

Utility theory provides the basis for demand theory, and as such, has undergone parallel developments. Jeremy Bentham (1748-1837), the leading philosopher of utilitarianism, advocated the concepts of measurable utility and interpersonal comparison. His guiding principle was "the greatest happiness principle" [Stark, p. 91, 1952], now commonly known as maximization of utility. The government's role in utility maximization was to ensure "the greatest happiness of the greatest number of individuals belonging to the community in question [Stark, p. 92, 1952], according to Bentham. This theory dealing with measurable, i.e., cardinal utility continued for over a hundred years; through Gossen (1810-1858), Jevons (1835-1882), Walras (1834-1910), Menger (1840-1921), and Marshall (1842-1921).

In 1854, Gossen presented a theory of consumer behavior based on three principles, which were later rediscovered independently and compiled into marginal utility theory by Jevons, Walras, and Menger [Gossen, 1854]. Gossen's first law set out the concept of diminishing marginal utility with respect to a single commodity. The second law stated that an individual would have maximized his utility from spending all his/her income only if the utility gained from the last item bought was the same for each commodity. Derived from the first two laws, Gossens' third law stated that a commodity has a subjective value, which diminishes with each additional unit owned, decreasing eventually to zero [Gossen, 1854]. Jevons [1924], Walras [1954], and Menger [1950], all working independently, then set out a theory of marginal utility in the 1870s.

In the late 1800s and early 1900s, Marshall (1842-1924) [1922] compiled and refined the elements set out by the earlier economists. In his theory of value, Marshall showed how the demand for a commodity is dependent upon the consumer's utility, where diminishing marginal utility occurs with each additional purchase. From here, he went on to develop price and demand and supply relationships. Marshall's work developed microeconomics into a comprehensive theory, although, even he recognized it was perhaps an oversimplification, since complementary and competitive goods were not taken into account and marginal utility of money was assumed to be constant [Hicks, 1946].

Economists had difficulty accepting the theory of value even before Marshall's work. Edgeworth (1845-1926) criticized Jevons' development of marginal utility and in so doing, invented indifference curve analysis [Edgeworth, 1881]. Based on work done by Walras and using Edgeworth's analysis, Pareto (1848-1923) [1909; Hicks, 1946] further developed analytical economics based on ordinal, rather than cardinal, measures of utility, focusing on complementary and competitive market such that the ratios of the marginal utilities of commodities exchanged would equal the ratio of the prices. Hence, an optimum point of exchange could be defined without comparing interpersonal total utilities [Hicks, 1946]. Although his work remained unnoticed for about thirty-five years, Slutsky (1880-1948)[1915] showed how the concept of ordinal utility could be used to build a comprehensive theory of consumer behavior, without the underlying assumption of measurable utility [Hicks, 1946]. Hicks (1904-) and Allen (1906-) discovered Slutsky's work and based upon it, showed how indifference curves could be used to analyze consumer behavior in an ordinal context [Hicks and Allen, 1934]. Hicks and Allen were not entirely original in their work, since so much of it was a restatement of Slutsky's earlier piece. It did, however, bring the concept of ordinal utility to the forefront of the profession.

With the recognition and general acceptance of ordinal utility theory, development of the dual approach to utility maximization was a natural extension of theoretical research. Slutsky [1915] presented the first discussion showing how the cost function could be used as an alternative to the utility function for a representation of preferences, but again, it was not recognized until Hicks and Allen presented it later in their 1934 article. Other substantial works on the dual approach to utility maximization may also be found in Samuelson [1947], Hotelling [1935], and McKenzie [1956-7].

After Hicks and Allen, Samuelson [1938] further developed the theory of consumer behavior by presenting an analysis based only on information obtained from consumers when actual choices were made under various income-price situations. This "revealed preference" analysis enabled the "law of demand," i.e., "that compensated demand functions can never slope upwards" [Deaton and Muellbauer, p. 44, 1980] to be proven, without having to assume measurable utility and without having to construct indifference curves. Such analysis permits consumer behavior study outside the constraints of individual utility definition and/or measures. Houthakker [1950] continued revealed preference work and proved some of the axioms set forth by Samuelson [1938].

While refinement of consumer behavior under certainty was occuring, an analysis of consumer behavior under uncertian conditions was being developed. Work done in the relatively new area of choice under uncertainty was based upon much earlier research by Daniel Bernoulli (1700-1782). Bernoulli's hypothesis states that the decision of an individual on whether or not to accept a certain gamble, depends upon the level of utility attached to the sums of money involved; not just the sums, themselves [Dillon, 1971]. Based on this hypothesis, the approach of the theory of choice under uncertainty is to then maximize expected utility.

The Bernoullian hypothesis was not utilized until much later, when Knight's (1885-1973) [1921] influenced work, distinguishing the difference between risk and uncertainty was presented.[5] His work was later followed by Ramsey [1931] and von Neumann and Morgenstern [1947]. However, it was not until Savage's [1954] work of *The Foundations of Statistics* that the economics profession began to recognize the theory of choice under uncertianty. Later pieces followed by Raiffa [1968], Arrow [1970], Degroot [1970], and Dréze [1974].

Von Neumann and Morgenstern's work in 1947 did, however, set forth a new cardinal utility theory[6] for the ranking of alternatives involving known probabilities. Out of von Neumann and Morgenstern's work, others [Bell, Keeney, and Raiffa, Eds., 1977; Fischer, 1979; Keeney, 1975, 1976; Keeney and Raiffa, 1976] have developed cardinal utility measures based on Bernoullian decision theory. A good overview of utility theory based on Bernoullian analysis may be found in Dillon [1971] and in Chapter 4 of Anderson, Dillon, and Hardaker [1977].

Prior to and after such research in Bernoullian theory, work in the area of psychophysics[7] had been developing. The founder of psychophysics, Gustav Fechner [1897], built upon earlier work by E. H. Weber to develop the "fundamental law of psychophysics," which, as

---

5/ Uncertainty exists when there is more than one possible outcome to a course of action, where the form of each possible outcome is known, but the probability of obtaining any one outcome is not known. Risk defines a situation in which the probabilities of obtaining certain outcomes are known [Baumol, 1977].

6/ Von Neumann and Morgenstern's cardinal utility measure was in no way related to the neoclassical cardinal utility measures, as discussed earlier.

7/ Psychophysics is a branch of psychology which studies the effect of physical processes upon the mental processes of an organism [Guralnik, Ed., p.1176, 1978].

Schumpeter [1954] noted, was "formally identical" [p. 1058] to Bernoulli's hypothesis[8] regarding marginal utility of income. Thus, both the Weber-Fechner Law and Bernoullis hypothesis use a logarithmic function to describe the relationship between a sensation or utility and stimula [Schumpeter, 1954]. Such a conclusion implies that the Weber-Fechner Law is a semi-log function (if Schumpeter's interpretation of Bernoulli's hypothesis is correct). The Weber-Fechner Law would then be as Osborne [1959] has stated: that equal ratios of physical stimulus, for example, sound frequency or light intensity, correspond to equal intervals of subjective or perceptual sensation, such as brightness or noise.

However, other authors have interpreted the Weber-Fechner Law differently. According to Stevens [1966], the Law states that "equal stimulus ratios produce equal perceptual ratios" [p. 530]. Much later, Breault [1981] utilizes Schumpeter's quote, which states the identical nature of Bernoulli's hypothesis and the Weber-Fechner Law, to link the psychophysicists' work to Bernoulli's hypothesis that

---

8/ As given by Schumpeter [1954], Bernoulli's hypothesis is as follows:

$$dy = k \frac{dx}{x}, \text{ or } \frac{dy}{dx} = \frac{k}{x},$$

where k = factor of proportionality
x = individual income
y = satisfaction derived from income.

Consequently,

$$y = \frac{b}{a} k \frac{dx}{x} = k \ (\log b - \log a) = k \log \left(\frac{b}{a}\right),$$

where a = threshold level of income necessary for existence
b = level of income $(b > a)$
y = total satisfaction

utility of income exhibits diminishing marginal utility.

However, Stevens' definition of the Weber-Fechner Law is not identical with Bernoullis's hypothesis, since Stevens' interpretation results in an approximately logarithmic function of multiplicative form. Such a function is "approximately logarithmic" (as opposed to logarithmic) because, the functional relationship postulates equal porportional changes (satisfaction) for given proportional changes (stimuli), instead of equal proportions for given logarithmic changes. [Alexander, 1961]. Application of either functional relationship will yield nearly identical results, as long as the proportionate changes are very small. Hence, as the proportionate changes in some stimuli approach zero, the resultant functional relationship approaches one of a logarithmic form. Such a result is in accordance with a basic concept of the Weber-Fechner Law (as defined by Stevens); that is, the proportionate stimulus change is one that a person can just barely discern, referred to as a "just noticeable difference" (JND). Employing the concept of a JND which may be transformed to linear data, permits analysis of data in a logarithmic context, instead of in its original curvilinear form.

Empirical Approaches to Utility Estimation

Thurstone [1927] was the first to develop a method for measurement of perceived stimuli, albeit, an indirect method, based upon the Weber-Fechner law. The Fechner-Thurstone approach defined the "Fechnerian scale of length," which is obtained by counting off "units of variability" of human judgements, referred to as just-noticeable differences (JND). Such a scale is an approximate logarithmic function of physical length, where variability of judgement, i.e., the JND, is roughly proportional to the magnitude of the stimulus [Thurstone, 1927, 1959]. Hence, even though values of subjective sensations are not measurable, changes in sensation are, since they can be measured experimentally and thus fulfill the measurability criteria, stated earlier [Osborne, 1959].

Eckman [1956, 1959, 1962] showed that Thurstone's scale of JND was an approximately logarithmic function and demonstrated that on quantitative continua, the variability, in subjective units, tended to increase as a linear function of the subjective (perceived) magnitude. During the same time, Stevens [1953, 1957, 1959, 1963] developed a method, called magnitude estimation, to directly measure an individual's marginal utility for various stimuli. Magnitude estimation techniques rest on a mathematical function, i.e., a power function, which describes the relationship between sensation and stimuli. The power function, as developed by Stevens, is shown as

$$\psi = k\ \phi^{\beta} \tag{1}$$

where ψ = perceived sensation magnitude, beginning at some threshold level,

k = constant specifying the unit of scale

ϕ = physical stimulus

β = power exponent determining the relationship between environmental or physical stimulus and the perceived magnitude, if equal stimulus ratios produce equal perceptual ratios (i.e., the law of proportionate change) [Stevens, 1966]. Hence, a proportionate change in ψ for a ratio change in ϕ is constant; so that if, for example, there was a proportionate increase in temperature, ϕ, the perceived increase of heat would diminish with each additional temperature increase, but the relative change, β, in ψ for a change in ϕ would remain the same.

The power function, as stated above and using Stevens' definition of the Weber-Fechner Law, may take the form of a double log function,

$$\ln \psi = \ln k + \beta \ln \phi \tag{2}$$

where the exponent, β, defines the slope of the line. Using the previous heat-temperature example, the stimulus-sensation relationship may be roughly shown in Figure 1 (for $\beta < 1$).

Galanter [1963] was the first to attempt to measure utility of money using the psychophysical measures of magnitude as set forth by Stevens. His study and others that followed, focused on determining the marginal utility for money for the power function, defined as in equation (1), where

$$\psi = U = \text{utility}$$

$$\phi = D = \text{money, or dollars.}$$

However, Galanter obtained only three data points at equal log intervals on the dollar continuum, from which he estimated the equation,

$$U = 3.71\ D^{0.43}. \tag{3}$$

Galenter's analysis implies that the marginal utility of money is a decreasing function. The methodology underlying this result has met with much skepticism and disapproval in the economics profession (for

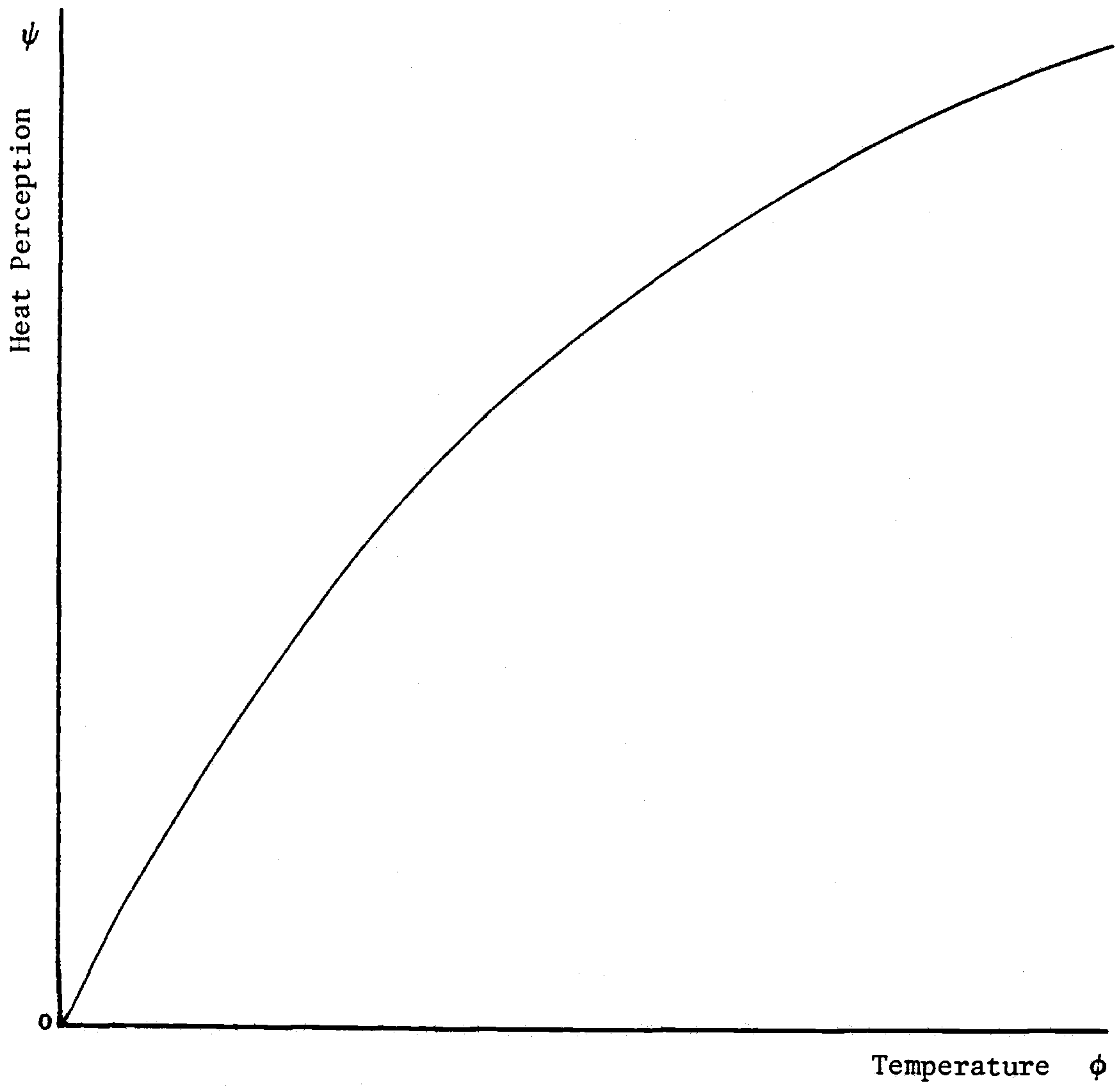

Figure 1. Example of stimulus-response relationship defined by a power function ($\beta < 1$)

example, see Weber [1975]). The experiment has been repeated and verified [Stevens, 1972; Galanter, 1974, 1975; Galanter and Pliner, 1974]. Besides, estimating the marginal utility of money, Stevens [1969] had done an earlier experiment to test the subjective intensity of taste, using the power function. Later, Hamblin [1971] utilized the power function to estimate utility of wages received.

All the psychophysical studies described above have measured only one stimulus when estimating a stimulus-sensation relationship. While such research has been invaluable for verification of the power function as an appropriate representative of subjective stimuli, many policy problems involve conflicting objectives defined over multiple values or attributes. Earlier research by Bell [1974] attempted to determine and quantify preferences for a forest region that was subject to outbreaks of Spruce Budworm. Conflicting objectives occurred among the logging industry, environmental groups, and professional foresters outside the logging industry. However, by focusing on several conflicting variables, his study forced individuals to think about and question which goals and objectives were most important in maintaining the forest; an important first step in actually defining a value function.

Keeney [1976] outlined several environmental problems, involving multiple conflicting objectives, in which preferences were quantified through use of a multiattribute utility model. Bernoullian decision analysis in the context of such a model depends upon (1) the probabilities of various possible consequences resulting from each alternative choice and (2) the relative desirability of those possible consequences. Keeney refers to this as an "impact model" and subsequently develops a "preference model," which quantifies an individual's preferences into a utility function. When multiple objectives are involved, the degree to which each objective is met is indicated by a measure of effectiveness or attribute. This multiattribute utility function is then, an objective function scaled in a manner such that the expected utility calculated for an alternative is an appropriate measure of the desirability of that alternative, in cases involving uncertainty [Keeney, 1976]. A multiattribute utility analysis is appropriate when there exists "(1) multiple objectives, (2) uncertainties about the impact, (3) impacts over time, (4) many impacted groups with diverse interests, and (5) multiple decision makers" [Keeney, p. 5, 1976].

Rausser and Yassour [1981] also apply Bernoullian decision analysis in specifying a multiattribute framework, emphasizing conflicting objectives and uncertainty, for determining price policy for rice in the Philipines. The value of presenting such a framework for analysis may be to; (1) provide focus for major policy conflicts, (2) provide tradeoff values among conflicting objectives, and (3) present subjective perceptions among groups affected by certain policies [Rausser and Yassour, 1981]. Additionally, psychophysicists, Hamblin, Clairmont, and Chadwick [1975] use the multiattribute framework to test hypotheses about multivariate utility equations with regard to gambling.

All such multiattribute frameworks based on von Neumann and Morgenstern's utility theory, as are the frameworks described above, utilized direct techniques for utility estimation, which again, are based on the power function set forth by Stevens, but involve more than one stimulus. A multiplicative/multiattribute power function is used, such that

$$\psi = k \prod_{i=1}^{n} \phi_i^{\beta_i} , \qquad (4)$$

where ψ = perceived magnitude, beginning at some threshold level

k = constant specifying the unit of scale

ϕ_i = physical stimulus

β_i = power exponent determined by the physical stimulus

i = 1,...,n number of stimuli.

Hamblin and Smith [1966] use the multiplicative power function to estimate a stimuli/response relationship between status of graduate students and of professors, as a function of teaching ability, publication effort, length of experience in the discipline, social interaction, etc.

Gum [1973] applies the work done by psychophysicists to utility estimation of public goods, specifically environmental aesthetics, where direct prices to the consumer are zero. Thus, as in the psychophysical literature, price is not a factor in determining which aesthetic qualities affect utility. Gum utilizes Metfessel's [1947] general allocation test by asking an individual to allocate 100 points among various attributes associated with water quality aesthetics, as a means of defining preferences. The multiplicative power function, as defined in equation (4), is used, with a restriction that the sum of all β_i equal 1.00. Thus, the function is homogeneous to degree one, following the law of proportionate change. Judge [1975] also utilizes the psychophysical approach for quantifying public input related to water resource planning and for defining the subsequent "satisfaction function". Gum, Roefs, and Kimball [1976] again use Metfessel's methodology and the power function to estimate satisfaction levels associated with aesthics, recreation, and economics. Arthur [1977, 1981] and Gum, et al. [1982] also use the power function, based on the law of proportionate change, to estimate preferences for predator (coyotes) control and for water quality improvement projects, respectively.

Summary

The theory of utility estimation has followed a long and complex route since its inception over 200 years ago; one that is much too long to present in detail here. However, in this brief overview, techniques for utility estimation have taken, somewhat, a full circle; through economists and through psychophysicists, who have done more in recent years to empirically estimate utility than have economists. Empirically estimating preferences may prove useful in policy analysis, where use of subjective indicators as "bellweathers" would perhaps enable planners to approach issues in a more timely fashion, rather than wait for people's behavior to point out a problem [Knox, 1979]. Subjective social indicators may then be very appropriate "indicators as basic orienting instruments, identifying and clarifying the broad issues at stake in the location and allocation of public goods" [Knox, p. 303, 1979].

With Knox's view in mind, this research continues in its analysis of public preferences for water allocation by presenting the theoretical underpinnings of the analysis in the next chapter, followed by the methodology and its results.

CHAPTER III

THEORY OF CONSUMER BEHAVIOR

Introduction

The theory of consumer behavior and specifically, utility theory, has undergone a great deal of change since its development by Bentham and the early cardinalists (i.e., Gossen, Jevons, Walras, Menger). Utility measurement in the context of the cardinalist school was synthesized by Marshall in the early 1920s. After being confronted with the ordinalist approach of non-measurement, formulated by Samuelson, a new cardinalist approach involving cases under uncertainty was presented by von Neumann and Morgenstern. Both the neoclassical and the more modern approach were developed around indirect measures of utility. Psychophysicists, in contrast, set forth a technique for directly measuring utility or perceived satisfaction, based on stimulus/response relationships.

This chapter will first discuss the theory of the early cardinalists and their approach to utility measurement, after which, the theory behind von Neumann-Morgenstern's cardinalist approach will be presented. The final section of this chapter will focus on the psychophysicists' approach to utility measurement, as it is the approach most relevant to this particular research.

Indirect Utility Measurement - Neoclassical Cardinalists

While developing the foundations of consumer theory, early day utilitarians (cardinalists) became immersed in the problems of explicit utility measurement and of aggregation of individual utility. Such concepts were central to the cardinalists' school of thought and therefore will be the focus of a brief discussion here.

One of the cardinalists' basic assumptions regarding consumer behavior was that of perfect information, where all decisions were made with certainty. The cardinalist framework for utility measurement was one, then, of a deterministic nature; where an individual's consumption of goods was considered to result in some psychic satisfaction, the level of which could be measured in units, referred to as utils. As a result, utility was measured on an absolute scale, according to some defined utility function, unique for every individual. However, because measurements were well-defined, both interpersonal comparison and aggregation of utilities were assumed. Aggregation of maximized individual utilities was used as a measure of optimal social well-being, reflecting Bentham's "greatest happiness for the greatest number" principle.

While the presentation of well-defined utility measurements was one aspect of the cardinalists' theory, development of the general law of diminishing marginal utility was probably their most significant contribution to consumer behavior theory. Observed consumer behavior led to such a development, which mathematically implied the existence of concave total utility functions and surfaces, with positive first derivatives, evaluated for any value of the argument and with negative second derivatives (which implies a function increases in its arguments at a decreasing rate). This implies, for a strictly quasi-concave function (which is generally assumed), that

$$U = f(x_1, x_2), \tag{5}$$

where U = utility

x_i = some commodity

i = 1,2,

then

$$2\, f_{12}\, f_1 f_2 - f_{11} f_2^2 - f_{22} f_1^2 > 0, \tag{6}$$

where f_1, f_2 = first order partials evaluated at some x_1, x_2

f_{11}, f_{22} = second order partials evaluated at some x_1, x_2

f_{12} = second order cross-partials evaluated at some x_1, x_2 [Henderson and Quandt, p. 11, 1980].

This concept carried over to the ordinalists and has continued to be a useful part of present day utility theory.

Indirect Utility Measurement
von Neumann-Morgenstern "Cardinalists"

Von Neumann's and Morgenstern's approach to utility theory and utility measurement is a cardinal approach in that cardinal, by definition, refers to a numerical measure. These measures, however, are not scaled by absolute units, as are earlier cardinalist measures. Consequently, the two measurement techniques bear little resemblance to one another.

The von Neumann-Morgenstern or Bernoullian utility theory associates the outcome of each uncertain event with a known probability[9] to determine the expected value and thus, calculate an individual's expected utility when faced with given alternatives. Bernoulli's Principle (postulated in 1738) is synonymous, then, with the Expected Utility Theorem, set forth by von Neumann and Morgenstern in 1944 (as a rediscovery of Bernoulli's work). The Theorem states that a utility function, U, exists, which associates a single index number with any risky prospect faced by the decision maker; assuming the decision maker's preferences do not violate axioms of ordering, continuity, and independence [Dillon, 1971]. Such axioms are the underpinnings of Bernoullian theory and are, as briefly stated by Dillon [1971]:

(1) Ordering: An individual's order of preferences among risky alternatives may be defined, whereby the individual prefers either outcome G_1 to G_2, or prefers G_2 to G_1, or is indifferent between the two. However, if he/she is faced with three risky outcomes and prefers G_1 to G_2 and prefers G_2 to G_3, then he/she will also prefer G_1 to G_3. (An individual may also be indifferent to all three prospects.)

(2) Continuity: If an individual prefers G_1 to G_2 to G_3, then there exists some unique probability, p, such that he/she is indifferent between G_2 and a gamble with p probability of yielding G_1 and is indifferent between G_2 and a gamble with (1-p) probability of yielding G_3.

(3) Independence: If G_1 is preferred to G_2 and G_3 is another

9/ When the outcome of each uncertain event is associated with a known probability distribution, the event is then defined as risky, not uncertain.

prospect, then a gamble with G_1 and G_3 as outcomes will be preferred to a gamble with G_2 and G_3 as outcomes; assuming the probability of G_1 and G_2 occurring is the same in each case.

When a decision maker's preferences are in accordance with the above axioms, the Expected Utility Theorem exhibits the following properties; again, as outlined by Dillon [1971]:

(1) If G_1 is preferred to G_2, the $U(G_1) > U(G_2)$. Conversely, if G_2 is preferred to G_1, then $U(G_2) > U(G_1)$.

(2) If some G has a set of outcomes {g} distributed according to some probability distribution f(g), then

$$U(G) = E\,U(G), \tag{7}$$

where U(G) = the utility of G,

E U(G) = the expected utility of G.

When f(g) is discrete,

$$E\,U(G) = \sum_g U(g)f(g), \tag{8}$$

and when f(g) is continuous,

$$E\,U(G) = \int_{-\infty}^{\infty} U(g)f(g)\,dg. \tag{9}$$

Since EU(G) is a weighted (by the probabilities) mean of U(G) and equal to U(G), only the first moment or mean of the probability distribution f(g) is relevant when analyzing choice under Bernoullian conditions. Additionally;

(3) A utility function is unique only up to a positive scalar transformation. Hence, utility is measured on an arbitrary scale, as a positive linear transformation of U(G) will represent U(G) just as well as the original.

The axioms and resulting properties of Bernoullian theory provide a method for ranking risky outcomes in order of preference, where the outcome most preferred is that with the highest utility. As a result, Bernoulli's Principle implies an individual maximizes his/her utility and, in the process, also maximizes his/her expected utility.

Direct Utility Measurement - Psychophysical Cardinalists

Psychophysicists do not and can not make the claim to "Bernoullian utility theory," as did von Neumann and Morgenstern in their 1944 piece. However, the basis for psychophysicists' direct utility measurement techniques is found in some of Bernoulli's work in gambling theory. Bernoulli hypothesized that an individual's utility for money would increase in a logarithmic fashion (implying that utility would increase at a decreasing rate, as money increased). Through indirect measurement, data were obtained which verified his hypothesis,[10] yielding an approximately logarithmic functional form [Hamblin, Clairmont, Chadwick, 1975]. Weber and Fechner later utilized Bernoulli's results to develop the "fundamental law of psychophysics", also a mathematical function of logarithmic form.

As noted in Chapter II, disagreement is found in the literature regarding the form of Bernoulli's log function, i.e., it may be expressed either in multiplicative or semi-logarithmic form. Psychophysicists and some economists [Arthur, 1978, 1981; Gum, 197 , 1976,

---

10/ Stigler [1950], however, says that Bernoulli's decision to use a log function was arbitrary. He states that Bernoulli made "a special assumption with respect to the shape of the utility curve for which there was no evidence and which he submitted no tests" [Stigler, p. 627, 1950].

1981] follow the multiplicative (equal ratio satisfaction-equal ratio stimulus) form, while some of the literature in operations research [Osborne, 1959; Alexander, 1961] follow the semi-log (equal ratios satisfaction-equal interval stimulus) form.

S. S. Stevens' work in the 1950s refined the earlier Weber-Fechner work, altering the "psychophysical law" from a logarithmic function to a power function, which describes the relationship between sensation and stimuli and is, as already described in Chapter II;

$$\psi = k\ \phi_i^{\beta_i}\ . \tag{10}$$

However, a slightly more complex form of this function, common in economic literature, known as the Cobb-Douglas function, is as follows;

$$\psi = k \prod_{i=1}^{n} \phi_i^{\beta_i}\ , \tag{11}$$

where ψ = perceived magnitude, of sensation, beginning at some threshold level (referred to as the level of satisfaction),

k = constant specifying the unit of scale,

ϕ_i = physical stimulus, i

β_i = power exponent determined by the physical stimulus, i

$i = 1,\ldots,n$ number of stimuli.

Additionally, $\sum_{i=1}^{n} \beta_i$ must equal 1.00.

Using the power (Cobb-Douglas) function to describe a sensation/stimuli relationship has both computational and theoretical vantages. First, the Cobb Douglas-type function conforms to the Weber-Fechner Law, i.e., that equal ratios of physical stimulus correspond to equal intervals of subjective sensation. This can be shown, using one variable as a example, by appealing to standard utility theory: where the elasticity of satisfaction is,

$$\varepsilon_{\psi} = \frac{\phi_1}{\psi} \cdot \frac{\partial\psi}{\partial\phi_1} = \frac{MU_{\phi}}{AU_{\phi}} = \frac{\phi_1}{\psi} \cdot \frac{\psi\beta_1}{\phi_1} = \beta_1 , \tag{12}$$

where ε_{ψ} = elasticity of satisfaction

MU = marginal utility

AU = average utility.

ε_{ψ}, a constant, is the relative change in satisfaction for a 1% change in stimulus.

The results above show that the Cobb-Douglas function is in a class of functions which exhibit constant elasticity of satisfaction. Additionally, any positive monotonic transformation of a linearly homogeneous function (i.e., a Cobb-Douglas function) will yield a class of homothetic functions, exhibiting the same result as that in equation (12).

Second, the relationships empirically tested in psychophysical literature that conform to Cobb-Douglas/power functions, exhibit diminishing marginal response to the stimulus. For example, Figure 1 of Chapter II shows the relationship between perceived heat and temperature, where heat is the satisfaction (ψ) measure and temperature is the stimulus (ϕ). As can be seen from the graph, the perceived change in heat increases at a decreasing rate as temperature continues to increase proportionately. Analogously, the satisfaction or utility an individual has gained through increasing the level of some attribute or stimuli can generally be said to follow the concept of diminishing marginal returns.

Finally, analysis of the Cobb-Douglas/power function within the context of the RCA Survey data leads to the result, that for a case where units of the budget are equal to units of the commodity, (i.e., a respondent's budget is given in gallons of water), the implicit price, p_i, would equal 1. Such would be true for any allocation of water which was exhaustive (i.e., all available water was allocated by the respondent). When the conclusion that $p_i = 1$ is coupled with the notion that an individual exhibits utility maximizing behavior, the constrained optimization of the power function can only occur when $\phi_i = \beta_i(100)$ for $i = 1,\ldots,n$. That is,

Show $\phi_1 = \beta_1(100),\ \phi_2 = \beta_2(100),\ldots,\ \phi_n = \beta_n(100)$,

where $\sum_{i=n}^{n} \beta_i = 1.00$ and $\sum_{i=n}^{n} \phi_i = 100$ (i.e., $\phi_i = \beta_i 100$),

$$\text{Max} \quad \psi = k\ \phi_1^{\beta_1}\ \phi_2^{\beta_2} \ldots \phi_n^{\beta_n} \tag{13}$$

$$\text{s.t.} \quad 100 - \sum_{i=1}^{n} p_i \phi_i = 0.$$

where ψ, k, ϕ_i, and β_i are defined as before, and

100 = total budget

p_i = price per unit of good or stimuli ϕ_i

i = $1,\ldots,n$.

$$\text{Max} \quad L = k\,\phi_1^{\beta_1}\,\phi_2^{\beta_2} \ldots \phi_n^{\beta_n} + \lambda\,(100 - \sum_{i=1}^{n} p_i\phi_i), \tag{14}$$

yields
$$\frac{\partial L}{\partial \phi_1} = \frac{\beta_1\psi}{\phi_{1-}} - \lambda\,p_1 = 0\ ,$$

$$\frac{\partial L}{\partial \phi_2} = \frac{\beta_2\psi}{\phi_2} - \lambda\,p_2 = 0,$$

$$\vdots \qquad \vdots \qquad \vdots$$

$$\frac{\partial L}{\partial \phi_n} = \frac{\beta_n\psi}{\phi_n} - \lambda\,p_n = 0,$$

$$\frac{\partial L}{\partial \lambda} = 100 - \sum_{i=1}^{n} p_i\phi_i = 0.$$

Therefore,

$$\frac{\beta_1\psi}{\phi_1}\ \frac{1}{p_1} = \frac{\beta_2\psi}{\phi_2}\ \frac{1}{p_2} = \ldots = \frac{\beta_n\psi}{\phi_n}\ \frac{1}{p_n} = \lambda, \tag{15}$$

which simply states that to maximize satisfaction, ψ, an individual must allocate his/her budget, M, such that the ratio of marginal satisfaction to price is equal for every commodity, attribute, or stimuli. Hence, the Lagrange multiplier, λ, may be interpreted as a measure of an individual's change in satisfaction for a proportionate (unit) increase in the budget. Equation (15) also leads to the conclusion, that since

$$\frac{\beta_1\psi}{p_1\phi_1} = \frac{\beta_2\psi}{p_2\phi_2} = \ldots = \frac{\beta_n\psi}{p_n\phi_n}\ ,$$

then;

$$p_2\phi_2 = \frac{\beta_2\psi}{\beta_1\psi} \quad p_1\phi_1 \ ,$$

$$\vdots \qquad\qquad \vdots$$

$$p_n\phi_n = \frac{\beta_n\psi}{\beta_1\psi} \quad p_1\phi_1 \ ,$$

$$100 - p_1\phi_1 - \frac{\beta_2}{\beta_1} \quad p_1\phi_1 + \ldots + \frac{\beta_n}{\beta_1} \ p_1\phi_1. \tag{16}$$

Multiplying equation (16) through by β_1,

$$100 \ \beta_1 = (\beta_1 + \beta_2 + \ldots + \beta_n) \ p_1\phi_1 \ , \tag{17}$$

results in;

$$\phi_1 = \frac{\beta_1}{\beta_1 + \beta_2 + \ldots + \beta_n} \quad \frac{100}{p_1} \ . \tag{18}$$

Since $\sum_{i=1}^{n} \beta_i = 1.00$,

$$\phi_i = \frac{\beta_i \ (100)}{p_i} \tag{19}$$

and $p_i = 1.00$, then $\phi_i = \beta_i(100)$ when the power function is at its constrained maximization.

Consequently, if water (100 gallons) is considered as a budget and the stimuli, ϕ_i, is that which results from the allocation of gallons of water, then any complete allocation (where all 100 gallons are allocated) is not weighted by price, since $p_i = 1$. In addition, the maximum gain in satisfaction (optimizing behavior) is assured, since each individual is allowed to allocate water in a manner that suits him/herself. Thus, maximization of utility, subject to the water budget and the stimulus (commodity). This allows use of limited data on preferences to derive rough, but plasuable utility functions for individuals.

Summary

The beginning of utility theory lies with Jeremy Bentham's "greatest happiness for the greatest number" principle, set forth in the late 1800s. From that principle, neoclassical utility theory developed; positing such concepts as perfect information, absolute utility measurement, and most importantly, the law of diminishing marginal utility. Neoclassical utility estimation is dependent upon observed consumer behavior in the marketplace, explicit price information, and conditions of certainty.

Later, von Neumann and Morgenstern developed a utility theory, based upon Bernoulli's work, for use under conditions of uncertainty. The foundation of the theory is found in the Expected Utility Theorem, where observed behavior is in response to risky alternatives.

Psychophysicists' work in utility measurement is based upon Bernoulli's hypothesis that an individual's utility for money increases in a logarithmic fashion. Bernoulli's hypothesis was applied to many other stimulus/response relationships. Such work resulted in the Weber-Fechner law, which led to use of the power function as a means to measure perceived (subjective) satisfaction, relative to some objectively measured stimulus. The psychophysicists' analysis does not depend upon explicit price information, when elicitating utility measures for individuals.

Considering the major theoretical frameworks for utility analysis, it will be shown that the psychophysical approach appears to be the most appropriate way to analyze this particular data set.

CHAPTER IV

METHODOLOGY OF CONSUMER PREFERENCE ANALYSIS

Introduction

The basis of the methodology to be used in analyzing the Resource Conservation Act (RCA) survey data, as briefly discussed in Chapter I, is found in the psychophysical literature and theory, discussed in Chapters II and III. Because explicit prices were not available to respondents of the marginal water allocation question (see footnote on page 7), a traditional neoclassical utility analysis is rendered inappropriate for this study. Additionally, Bernoullian/von Neumann-Morgenstern utility analysis is not applicable, since the allocational question was asked under conditions of certainty. However, the inability to utilize either of the "traditional" utility analyses does not necessarily render the data useless. The data are, in fact, preferences given by respondents, who are assumed to be rational. Hence, every individual's response represents a component of his/her underlying utility function, and therefore, is part of his/her resulting preference map.

The psychophysical methodology to be used for analyzing the given preferences will take advantage of the fact that each allocation response by each individual represents a single point of constrained utility maximization.

Data Description

The RCA survey was a comprehensive effort to assess the public's attitudes toward conservation policies. Some 7,010 adult individuals (18 years of age or older) in the U.S. were interviewed between October 19 and November 21, 1979 by Louis Harris and Associates. Those interviewed were chosen through a random, stratified, multistage, cluster sample design. Extra interviews were scheduled to allow for replacement of unwilling participants [Fisher, et al, 1979].

Once regional and area stratification was defined and interviews were scheduled, the respondents were randomly chosen from adults 18 years of age or older within each household. The distribution of sampling points, however, was weighted to guarantee that a minimum of 300 respondents would occur in each of the 16 cells defining the place or city-size of residency. Those 16 cells were divided into two variables (1) the geographic region of the country and (2) the size of city. Four geographic regions specified by SCS were; the East, South, Midwest, and West (Figure 2).

The relevant region for this analysis, is, however, the western part of the U.S., which includes the following states:

<u>West</u> - Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Idaho, Nevada, California, Oregon, Washington, Alaska, and Hawaii.

The SCS also defined four categories of city size, as follows:

(1) <u>city</u> or <u>urban</u> - single cities with populations of 50,000 or more, or twin cities where at least one city has a population of 35,000 or more and the total population is 50,000 or more,

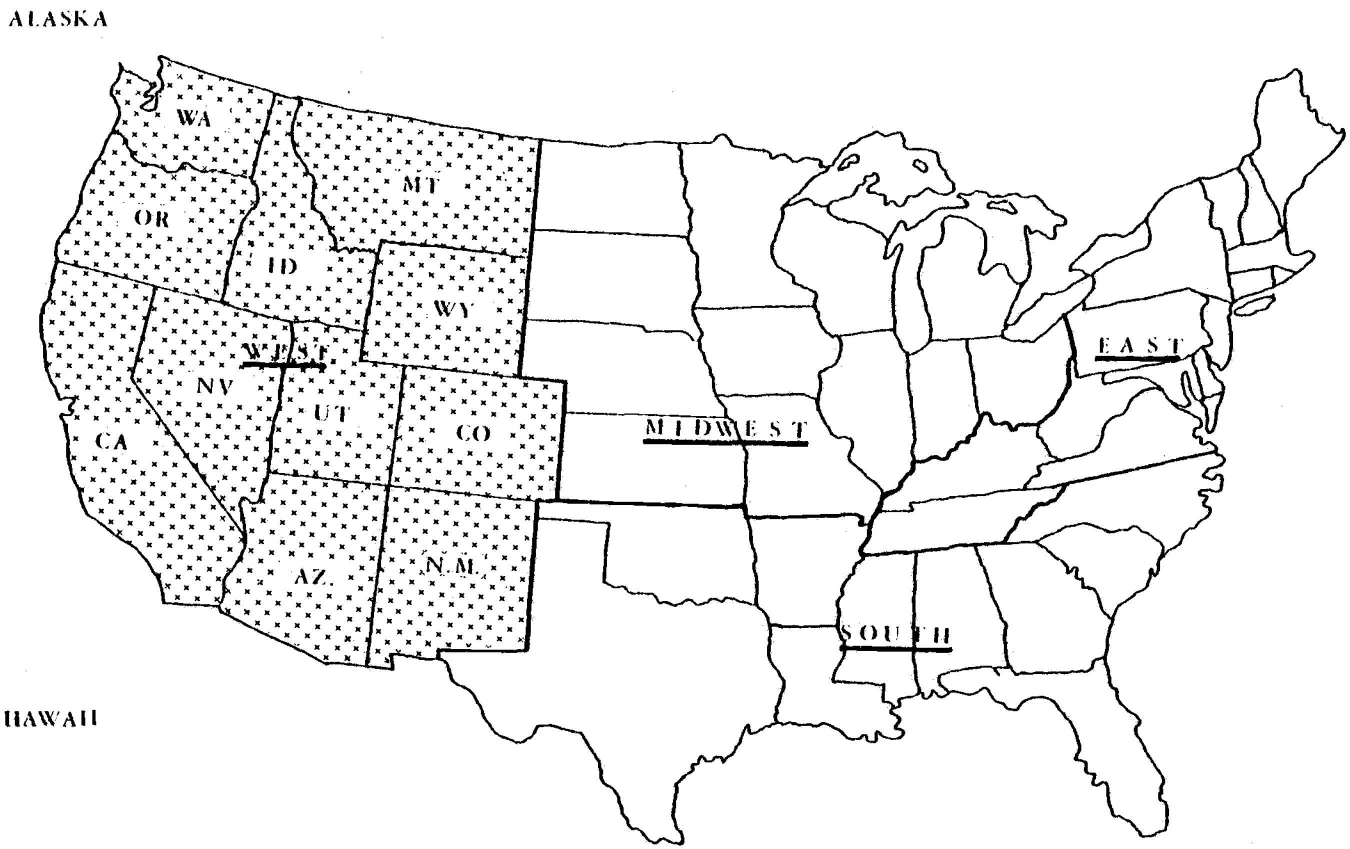

Figure 2. Regional definition of RCA Survey Respondents.

(2) suburban - not a "central city," as defined above, but that which is within an urbanized area,

(3) town - every city, town, or village with a population of at least 2,500 that is not within an urbanized area,

(4) rural - every place not included in one of the other three categories [Fisher, et al, p. 150-151, 1979].

Weighting the distribution of sample points among the 16 cells was necessary to reduce statistical bias inherent in simple random samplings over areas of widely differing population densities. The sampling techniques employed in the Harris survey results in an areal sample that better reflects varying population densities. Table 1 shows the distribution of sample points using the stratified cluster sample as a basis.

Data used for this analysis were, specifically, from the Western region only, but included all four city size categories. A total of 1,527 individuals were interviewed in the West, making up the total sample size for that region. City size distributions with the unweighted and weighted percentages relative to the total sample size of 7,010 were as shown in Table 2.

A variety of questions designed to assess the public's attitudes of and examine trends and conditions in soil, water, and other related natural resources were answered by 1,527 individuals in the Western region. The particular question from the RCA survey used in this analysis was designed to determine public preferences

Table 1. Proportionate (weighted) and actual sample point distributions.

A. Proportionate distribution of sample points based upon stratified cluster sample.

Region		Type of Place (City Size) Urban (188)	Suburban (177)	Town (92)	Rural (143)
East	(197)	63	67	24	43
South	(136)	42	23	27	44
Midwest	(162)	48	47	27	40
West	(105)	35	40	14	16

B. Actual distribution of sample points with oversampling of town and rural areas.

Region		Type of Place (City Size) Urban (177)	Suburban (158)	Town (110)	Rural (155)
East	(172)	52	48	29	43
South	(136)	42	23	27	44
Midwest	(162)	48	47	27	40
West	(130)	35	40	27	28

Table 2. Western region respondent distribution.

	Number of Respondents	Unweighted Percentage	Weighted Percentage
West	1,527	22	18
Urban	407	6	6
Suburban	474	7	7
Town	320	5	2
Rural	326	5	3

for the allocation of additional water[11]. Out of 1,527 individuals interviewed, 1,472 responded positively to the allocational question (i.e., allocated 100 gallons among the uses), while 55 individuals did not answer that particular question. The sample size for this analysis will then consist of 1,472 observations.

Methodological Technique

Preferences for competing uses of water were represented by the number of gallons every individual allocated to each use. Each allocation response is a representation of a respondent's unique underlying utility function. In turn, if an individual's response were plotted on a five-dimensional graph (one dimension per water use), a single point would result, which would represent one level of satisfaction on a utility surface. Since data exist that would reflect each individual's preference for the distribution of water, specification of the appropriate utility function is necessary. Such specification should permit analysis of responses in terms of

---

11/ (as in Chapter I) Question #17. "Here is a board which shows a number of uses for which water is in great demand. Now let's assume that there was enough water to meet the minimum needs for each of these uses. From each additional 100 gallons of water available, how would you divide up those gallons among these different uses? Suppose each of these cards stands for 5 gallons of water - 100 gallons altogether. Just divvy up the cards among the boxes shown on this board to show how you think these additional 100 gallons of water should be used.
The competing uses are:
(1) water for household use,
(2) water for industry and jobs,
(3) water for producing food,
(4) water which fish and wildlife need to live,
(5) water for developing energy resources"
[USDA, p. 12, 1980].

satisfaction, as developed by Bentham and later by, psychophysicists. Since the stated preferences represent a maximum level of satisfaction, at the margin, then the functional form, as follows, may be assumed;

$$S_i = f_i\ (k,\ g_H,\ g_I,\ g_A,\ g_{FW},\ g_E) \qquad (20)$$

where S_i = the measure of satisfaction for individual i,

k = constant

g_H = gallons allocated for household use

g_I = gallons allocated for industry and jobs

g_A = gallons allocated for food production

g_{FW} = gallons allocated for fish and wildlife habitat

g_E = gallons allocated for energy development

i = number of respondents 1,...,1,472.

The response data suggest a marginal allocation, which most completely satisfies the respondent, based on an individual's preference structure. That is, each individual's stated preference represents his/her optimal marginal allocation of water among the competing uses, as defined above. Any deviation from this will result in a sub-optimal marginal allocation, for that individual.

Based on empirical studies which have shown that nonmarket human values and preferences are best represented by a power (Cobb-Douglas) function, the methodological technique presented here will also utilize such a function [Breault, 1981; Arthur, 1978; Gum, et al. 1976; Hamblin, et al. 1975; Stevens, 1966, 1969; Hamblin and

Smith, 1966]. In work by Stevens [1966], which reviews methods used to gauge intensity of opinions and attitudes, the power function has been shown to best measure satisfaction levels for individuals, on a quantitative continuum.

The specific functional form measuring the level of satisfaction, then, is

$$S_i = k\, X_H^{g_H}\, X_I^{g_I}\, X_A^{g_A}\, X_{FW}^{g_{FW}}\, X_E^{g_E} \tag{22}$$

where S_i = level of satisfaction for respondent i, given some allocation

k = constant; or "welfare weighting"

X = some policy allocation of water (unknown to the respondent), for each use H, I, A, FW, E

g = respondent's allocation of water (as answered in Question #17) x 0.01, for each use H, I, A, FW, E

i = respondent 1,...,1,472.

Additionally, $\Sigma X = 100$ and $\Sigma g = 1.00$. The constant or "welfare weight", k, has a large effect on an analysis of this type, though its derivation lies outside the abilities of an economist. This analysis has treated the task of assigning a value of k as insignificant, that is, k simply equals 1. It has been assumed that welfare weights are equal for all groups over all demographic characteristics, i.e., no special significance is given to a response considering income level, occupation, educational level, etc. However, this analysis is only an example of how data may be treated to reflect a simple (as in this case) or complex welfare weighting scheme by decision makers. A more complex scheme may be desired by policy makers, but then the problems of whose utility should be scaled up or down, and how those weights should be appropriately assigned, arise. Such problems, however, are within the realm, at a practical level, of policy making.

Since the Xs are unknowns in the above equation, S_i can not initially be determined. However, the equation may still yield useful information when it is applied to a particular water allocational policy. For example, if an equal allocational policy is considered, i.e., $X_1 = X_2 = X_3 = X_4 = X_5 = 20$ gallons of water, then a correspondent level of satisfaction may be obtained from that policy. As before, the respondent's preferences, as given by the RCA data, equal g x 0.01, so that

$$S_i = k\ 20_H^{g_H}\ 20_I^{g_I}\ 20_A^{g_A}\ 20_{FW}^{g_{FW}}\ 20_E^{g_E}, \tag{22}$$

such that S_i may be determined for every respondent i. This methodological procedure was applied to examine the implications or impact of various allocational policies on respondents' satisfaction levels. Allocational policies were defined as follows;

P(1)	$20_H, 20_I, 20_A, 20_{FW}, 20_E$ }	all equal
P(2)	$80_H, 5_I, 5_A, 5_{FW}, 5_E$	emphasis on one sector
P(3)	$5_H, 80_I, 5_A, 5_{FW}, 5_E$	
P(4)	$5_H, 5_I, 80_A, 5_{FW}, 5_E$	
P(5)	$5_H, 5_I, 5_A, 80_{FW}, 5_E$	
P(6)	$5_H, 5_I, 5_A, 5_{FW}, 80_E$	

P(7) 21_H, 19_I, 26_A, 17_{FW}, 17_E average response

P(8) 4_H, 45_I, 3_A, 3_{FW}, 45_E

P(9) 45_H, 4_I, 45_A, 3_{FW}, 3_E emphasis on two sectors

where H = gallons allocated for household use

I = gallons allocated for industry and jobs

A = gallons allocated for producing food

FW = gallons allocated for fish and wildlife

E = gallons allocated for energy development,

and $H + I + A + FW + E = 100$.

The first policy represents the "egalitarian" allocational viewpoint, i.e., all 100 gallons are equally distributed among the 5 uses. Policies (2) through (6) were defined to determine the satisfaction level of all respondents when only one sector (i.e., H, I, A, FW, or E) (and usually only a very small group of individuals) is emphasized[12]. Policy (7) represents the average RCA survey response and policies (8) and (9), each, emphasize 2 sectors.

The number of different responses to the water allocation question was 594. There are, then, at least 594 various ways to develop a policy option. However, most decision makers charged with making policy are not at liberty to decide from such an array of alternatives. Usually, they are given only a few alternative policies,

---

12/ 0.204% of total sample allocated all 100 gallons to H
0.136% of total sample allocated all 100 gallons to I
0.408% of total sample allocated all 100 gallons to A
0.679% of total sample allocated all 100 gallons to FW
0.408% of total sample allocated all 100 gallons to E

from which one is chosen. Hence, for this study an attempt is made to look at only a few feasible options, in order to simulate actual decision making.

The impact of the various policies on a respondent's level of satisfaction is a function of S_i, as defined in equation (21) and of an individual's maximum level of satisfaction, Max S, defined as follows;

$$\text{Max } S_i = g_H'^{\,g_H} \; g_I'^{\,g_I} \; g_A'^{\,g_A} \; g_{FW}'^{\,g_{FW}} \; g_E'^{\,g_E} \qquad (23)$$

where $\text{Max } S_i$ = maximum level of satisfaction for respondent i

g' = respondent i's allocation of 100 gallons of water to uses H, I, A, FW, and E

g = respondent i's allocation of water to uses H, I, A, FW, and E x $\frac{1}{0.01}$

i = respondent 1,...,1,472

and $\Sigma g = 1.00$; $\Sigma g' = 100$.

It is possible to define $\text{Max } S_i$ as in the above equation, since it has been previously shown in Chapter III that when S (or ψ) is at a maximum, $g' = g(100)$ (or $\phi = \beta(100)$). Consequently, the impact of a water allocational policy on the public is a function of how that policy affects each individual's maximum level of satisfaction. Therefore, the public policy impact, PPI, is the percent of maximum satisfaction attainable for each respondent per policy, and is defined as follows;

$$PPI_{ni} = \frac{S_{ni}}{Max\ S_i}\ 100 \quad (24)$$

where PPI_{ni} = public policy impact of policy n on respondent i

S_{ni} = level of satisfaction attained by respondent i when policy n is implemented

Max S_i = maximum level of satisfaction for respondent i

n = public policy for water allocation, P(1),...,P(9)

i = respondent 1,...,1,472.

The PPI index, which is expressed as a percentage, was calculated for each respondent i, and is scaled from 0 to 100%. This corresponds to the vertical axis in Figure 3. However, there were groups of individuals, within the sample, that had common preferred allocations, leading to a common PPI value for a given policy alternative n. Additionally, the sample size of 1,472 respondents may be broken into R groups, each having a common preferred allocation, which implies a common PPI value. Within each of the R groups, there is some number or group of individuals, where each group represents a percentage of the sample $\frac{1}{4,472}$ and hence, represents a percentage of the sample with a common PPI. If these groups of individuals are ranked from those with the lowest PPI (0) to those with the highest (100), then the scale PS is formed (Figure 3). The PS scale is cumulative, in that, for example, the point

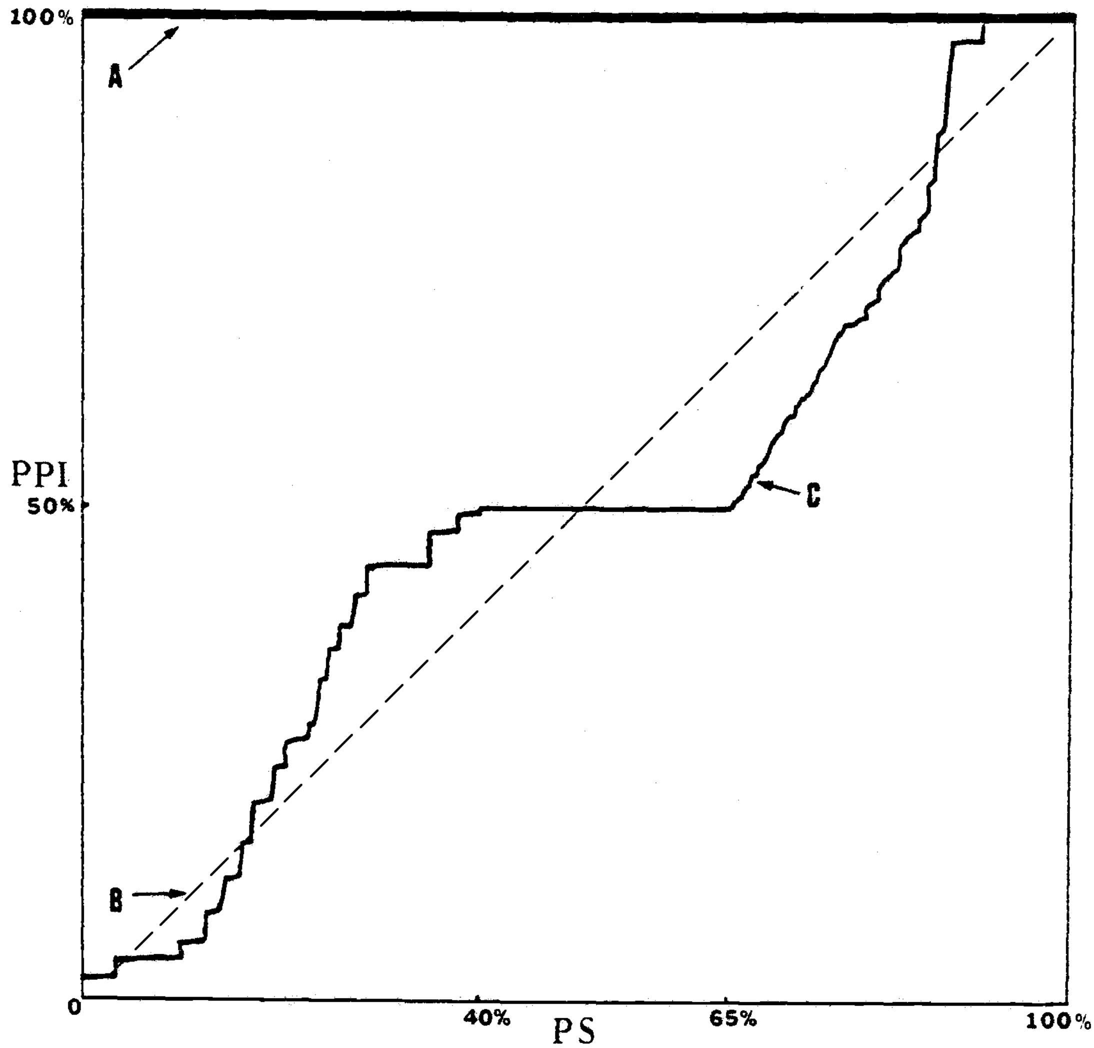

Figure 3. Percentiles of sample satisfied at a given PPI (PS), versus percentage of maximum satisfaction derived (PPI) for a given policy n

corresponding to PS = 65% and PPI = 50%, suggests that, with respect to curve C [Figure 3] 65% of the sample realized a PPI index of 50% or less of their maximum satisfaction. Additionally, the percentage of the total sample who achieved exactly 50% of their maximum satisfaction (PPI = 50%), would be $\frac{65 - 40}{100}$ = .25 or 25% of the sample.

Since the PS scale in Figure 3 takes into account all respondents, then the addition of these smaller (group) line segments equals 100%. Therefore, for a given suggested policy n;

$$\sum_{i=1}^{r} PS_i = \frac{\sum_{i=1}^{r} Q_i}{1,472} = 1 \;, \tag{26}$$

where Q_i = number of respondents in sub-groups R

1,472 = total number of respondents.

This implies that, regardless of the proposed policy n, there are always R preferred allocation schemes that were recorded.

The area under curve C in Figure 3, then, represents total consumer "satisfaction" derived from an associated policy. If the sum or integral over all sample percentiles were taken, i.e., the proportion of their maximum (constrained) satisfaction levels, the result would be an area under a Public Policy Impact (PPI) curve. Take, for example, the dotted 45 degree line, B, that is also shown in Figure 3, which represents a PPI curve for some given policy. (This curve is smooth to facilitate easy explanation.) It represents a situation where, given a certain policy, there is a 1% gain in the percentage of total satisfaction, as expressed by stated preferences, for a 1% change in sample percentile. Also, in comparing PPI curve A (across the top of Figure 3) to PPI curve B, it is clear that, if both policy options are feasible and are of the same cost, policy A should be chosen over policy B. The area associated with policy A is 10,000 or in decimal fraction, unity. As a result, the implication is that under policy A, consumers would enjoy 100% of their maximum satisfaction, while under policy B, they would derive only 50% (or 5,000).

An application of this methodological technique will be discussed in the following chapter.

Summary

The purpose of the methodological procedure as described above is to extract information from the survey data regarding consumer preferences, which could be useful in policy analysis. Although, Louis Harris and Associates did a detailed study on the results of the RCA survey, the objective of this research is somewhat different.

Louis Harris and Associates presented (in a summary of the report) mean responses of the entire Western region and of various subgroups with respect to water allocated among competing uses. From the reported mean responses, inferences were made regarding the population's allocational preferences. Some major results were as follows; (1) the public assigns the highest priority to farming (production of food) in allocating water resources, (2) as individuals receive proportionately more income from farming, the number of gallons of water allocated for the production of food increases, and (3) age and educational levels were important factors when discerning differences among all individuals, with respect to water allocation [Fisher et al. p. 50-52, 1979].

While such information may be interesting, it does little to help policy makers determine the effects of a specific allocational policy. It also does not provide policy makers with a method for explicitly taking into account effects of changes in social welfare weightings and the impacts on individual satisfaction levels, as a result of these weightings and the allocational policy.

This work specifically acknowledges the possibility of unequal welfare weightings, the existence of an underlying preference structure, and the possibility of a limited set of discrete policy alternatives. These features will allow policy makers to determine what percentage of the population would obtain a particular level of satisfaction, with implementation of a given policy, assuming appropriate welfare weights. Such knowledge should be far more useful than simple mean responses, when considering the impact of various policies upon the population.

CHAPTER V

RESULTS OF CONSUMER PREFERENCE ANALYSIS

Introduction

The results of the methodology using the power function will be presented and explained in this chapter. As is necessary with any research, a critique or discussion of the survey data will be presented, followed by a discussion of the methodology. Additionally, suggestions for future research will be made in the last section.

Results and Conclusions

The results of the methodology, as explained in the previous chapter, provide a clear, visual description of all individuals' level of satisfaction as related to the implementation of a given policy. However, there are underlying features of the resulting figures for policies (1) through (9), which are necessary to understand if such figures are to be interpreted correctly. Each figure, (1) through (9), shows PPI plotted on the vertical axis and PS on the horizontal axis. Recall that PPI is each respondent's percent of satisfaction that may be attained by a certain policy. As before, PS is defined as the percentage of all individuals satisfied, at a preferred allocation level, in increasing order, for a given policy. The resulting curve from the various plots will be called the public policy impact (PPI) curve.

As previously stated, the area under the PPI curve is the relevant measure necessary for comparison of different policies, (1) through (9). Table 3 provides a summary of all; (1) policies defined, (2) areas under associated PPI curves, and (3) the percentage of the total area that is within the PPI curve. The total area in which the PPI curve lies, equals 10,000 as calculated from percentages (i.e., 100% x 100%). Consequently, the area under the curve, given in Table 3, is a percentage of 10,000. For easier comparison of policies, the percentage of the area under the curve, relative to 100% of the total area, is also given.

Table 3 shows, then, that the area associated with PPI curve #7 is the largest, compared with the areas under all other curves. This implies that implementation of policy (7) (i.e., a policy based upon average survey responses in the West) would enable the population, as a whole, to achieve a higher level of satisfaction than would be possible if any of the other policies were implemented. However, such a result does not imply that policy (7) is the optimal policy out of all possible policies, if a different welfare weighting assumption is employed. Under different welfare weights, k, some other policy may yield a greater area under the PPI curve than that obtained with policy (7). Hence, that particular policy would make the population better off than would policy (7).

The welfare weights used in this analysis were equal; that is, each individual was assumed to be equally important in the decision making process, or alternatively, that the marginal utility of water was the same for all individuals. However, it has been argued that such a state seldom exists. Additionally, recommenda-

Table 3. Areas under the public policy impact curves for policies (1) through (9).

	Policy Description (%)					Area Under Curve	% of Total
Policy	House-holds	Ind & Jobs	Food Prod.	Fish & Wildlife	Energy Devel.		
1	20	20	20	20	20	8718.47	87.2
2	80	5	5	5	5	3921.57	39.2
3	5	80	5	5	5	3700.59	37.0
4	5	5	80	5	5	4795.60	48.0
5	5	5	5	80	5	3796.21	38.0
6	5	5	5	5	80	3627.30	36.3
7	21	19	26	17	17	8840.85	88.4
8	4	45	3	3	45	3761.21	37.6
9	45	4	45	3	3	5155.26	51.6

tion of equal welfare weights or any welfare weights at all, is not within the purview of the economist.

A welfare weighting is explicitly used (equal weightings) in this analysis, providing a basis for the allocation of water. If policy makers felt that equal weights were appropriate, then results from this work are valid for decision making; if not, an explicit system of weighting responses, according to criteria chosen by the decision maker, must be employed. Such weighting would change the level of the respondent's satisfaction, which then could alter, significantly, the policy used.

The resulting PPI curve for policy (1), i.e., 20_H, 20_I, 20_A, 20_{FW}, 20_E, is shown in Figure 4. It should be read, for example, that the 40th percentile of all respondents achieve 90% of their maximum satisfaction level, as shown in Figure 3 at point A. Implementation of this "egalitarian" policy would leave only less than 7.5% of the respondents in a position where they were unable to achieve even 50% of their maximum satisfaction level. Since the sample of respondents is a representation of the population, it could be inferred that only 7.5% of the entire Western adult population would be unable to reach 50% of their maximum satisfaction level. Thus, implementation of this policy would cause relatively few people to be upset, while most of the population would attain a fairly high level of satisfaction with respect to the allocation of water. (Approximately 80% of the population has an allocation preference scheme which would allow them to achieve approximately 80% of their maximum satisfaction level, under policy (1).)

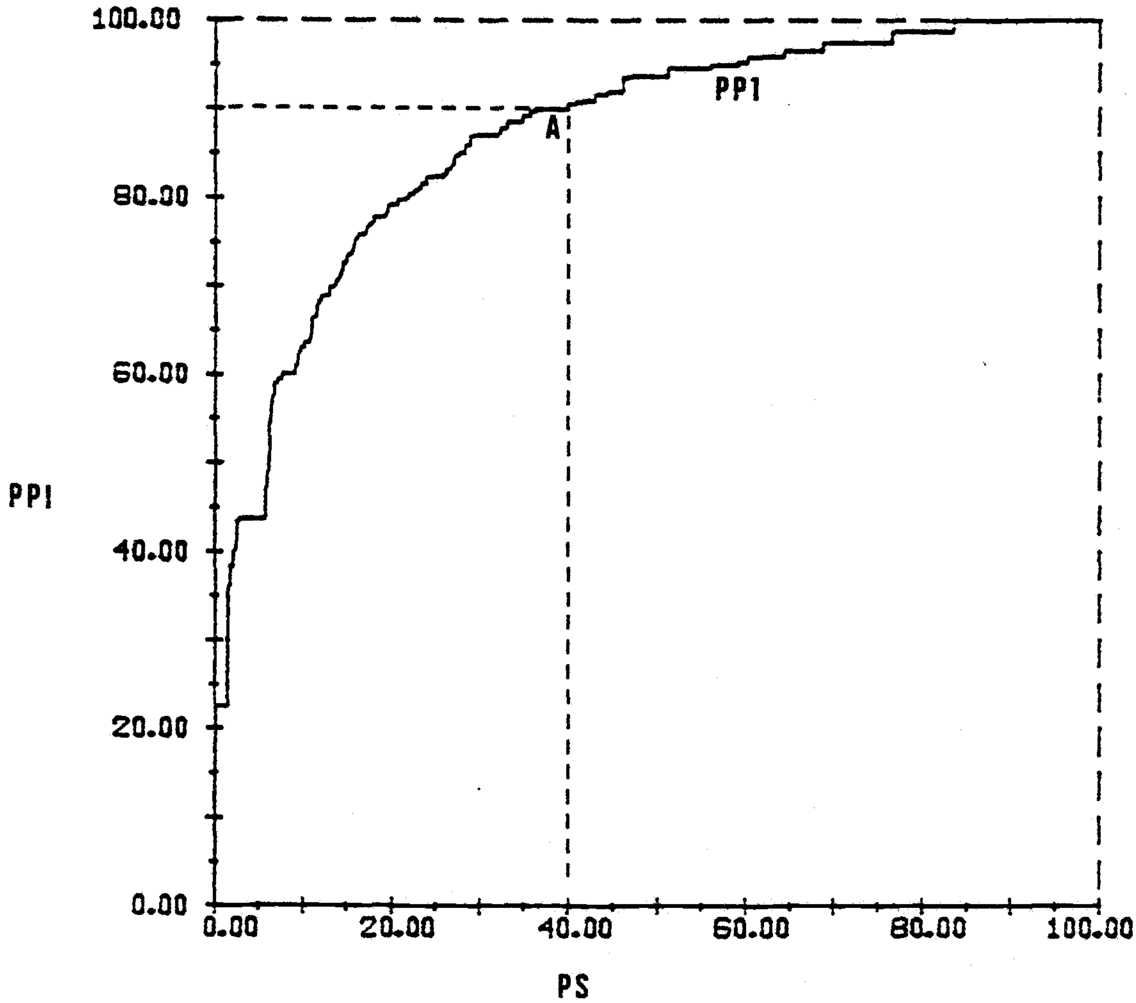

Figure 4. Public policy impact curve for allocation policy (1); 20_H, 20_I, 20_A, 20_{FW}, 20_E

Policies (2) through (6), shown in Figures 5 through 9, are sigmoid or S shaped, whereas policy (1)'s PPI curve is approximately exponentially shaped.

For every policy (2) through (6), the allocation scheme was such that 80 gallons was allocated to one use, while 5 gallons was given to each of the other uses. So, 80 gallons were allocated for: household use, H, under policy (2); industry and jobs, I, under policy (3); food production, A, under policy (4); fish and wildlife habitat, FW, under policy (5); and energy development, E, under policy (6). All other uses under each policy scheme received 5 gallons each.

Implementation of policy (2), (3), (4), (5), or (6) would satisfy very few people. For example, not until the 90th PS percentile is reached, do respondents achieve 50% or more of their maximum satisfaction level, as measured by PPI, under policy (2). Consequently, most people probably would feel as if they could be made much "better off", i.e., achieve a higher level of satisfaction, if a different policy was implemented.

Referring back to Table 3, the policies can be ranked according to area, from worst to best, in terms of the most satisfaction achieved by all respondents. Hence, from worst to best, i.e., least to most area, the policies are (6), (3), (5), (2), and (4). It is clear from this ranking that, given equal welfare weighting, a divergence from an egalitarian or "average" type of policy would most likely be sub-optimal from a societal standpoint. Not only this, but among sub-optimal policies, individuals would be least satis-

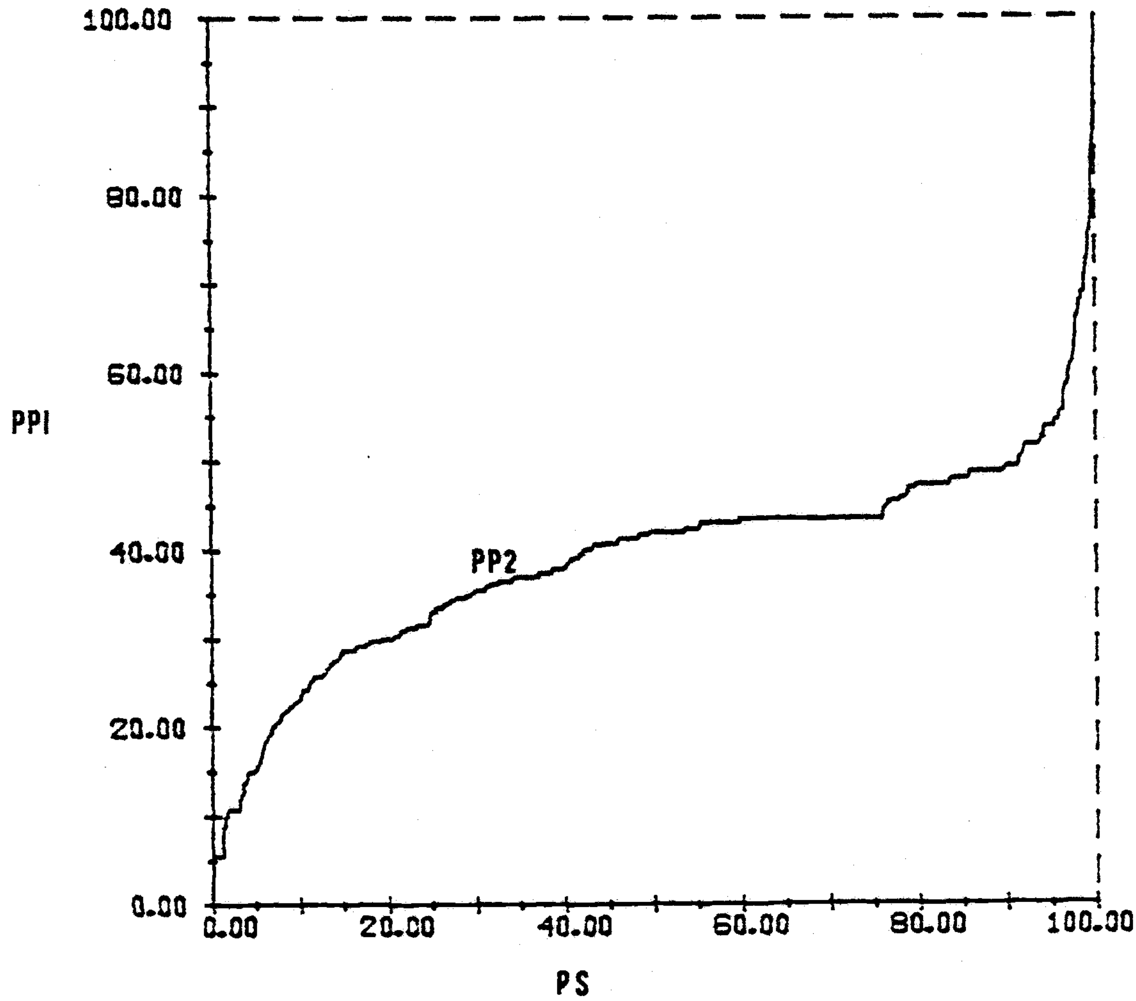

Figure 5. Public policy impact curve for allocation policy (2); 80_H, 5_I, 5_A, 5_{FW}, 5_E

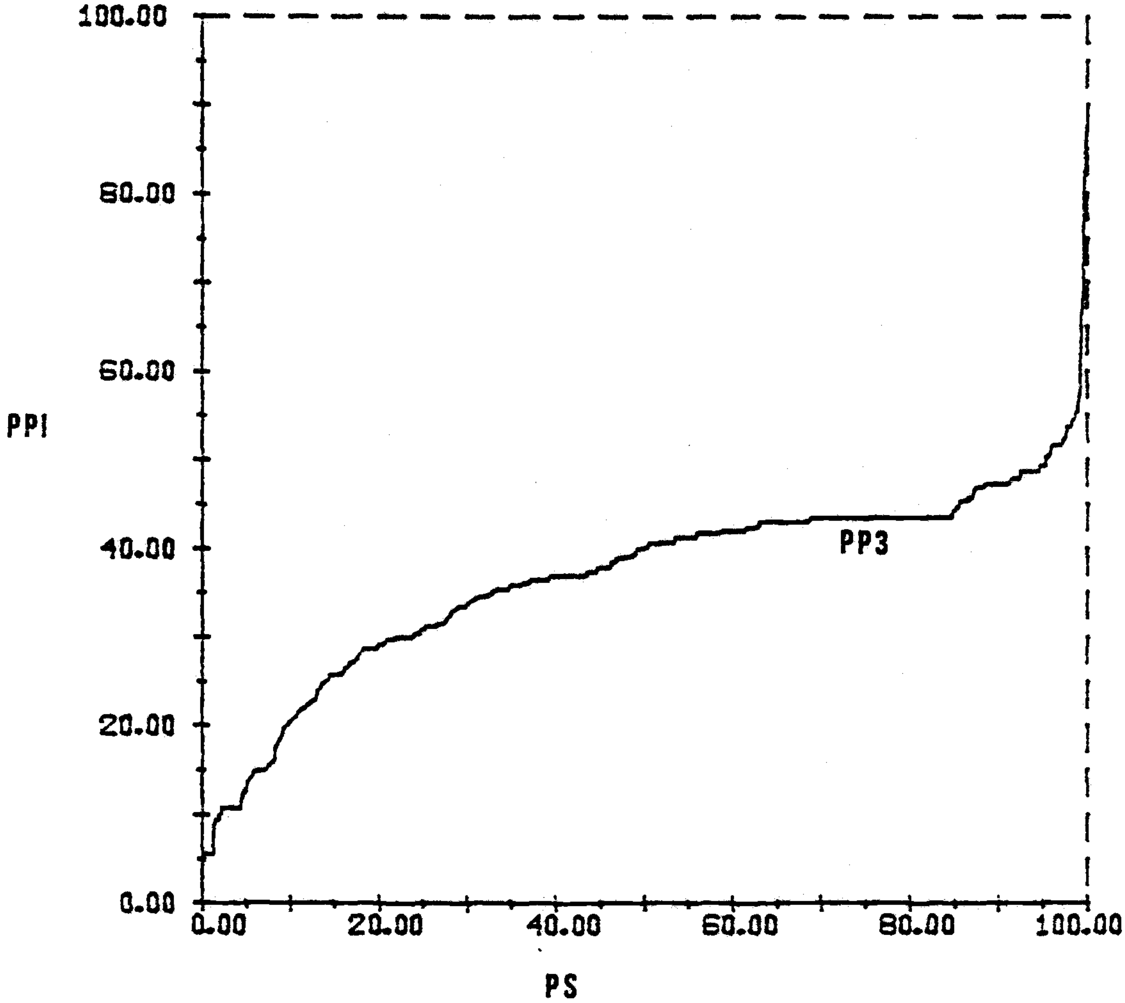

Figure 6. Public policy impact curve for allocation policy (3); 5_H, 80_I, 5_A, 5_{FW}, 5_E

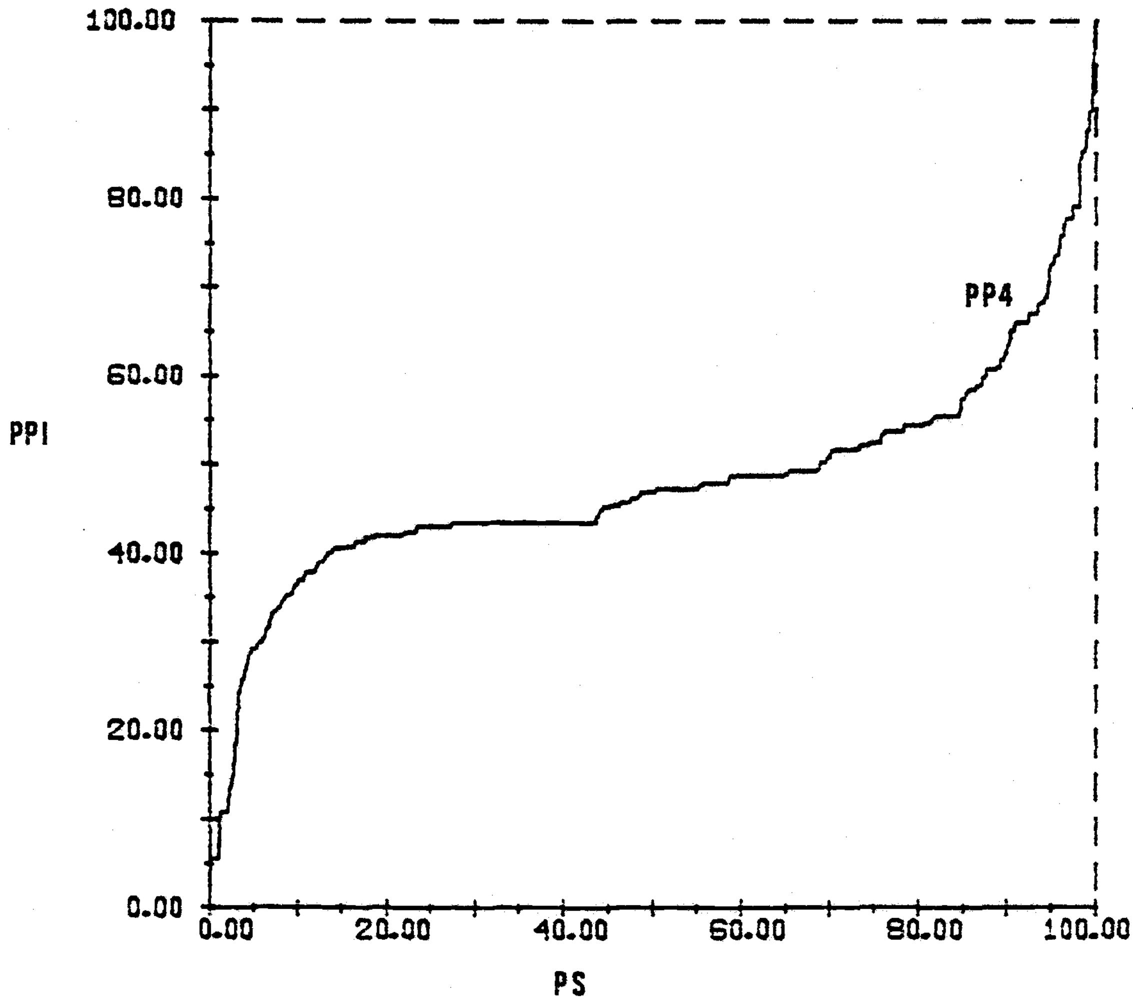

Figure 7. Public policy impact curve for allocation policy (4); 5_H, 5_I, 80_A, 5_{FW}, 5_E

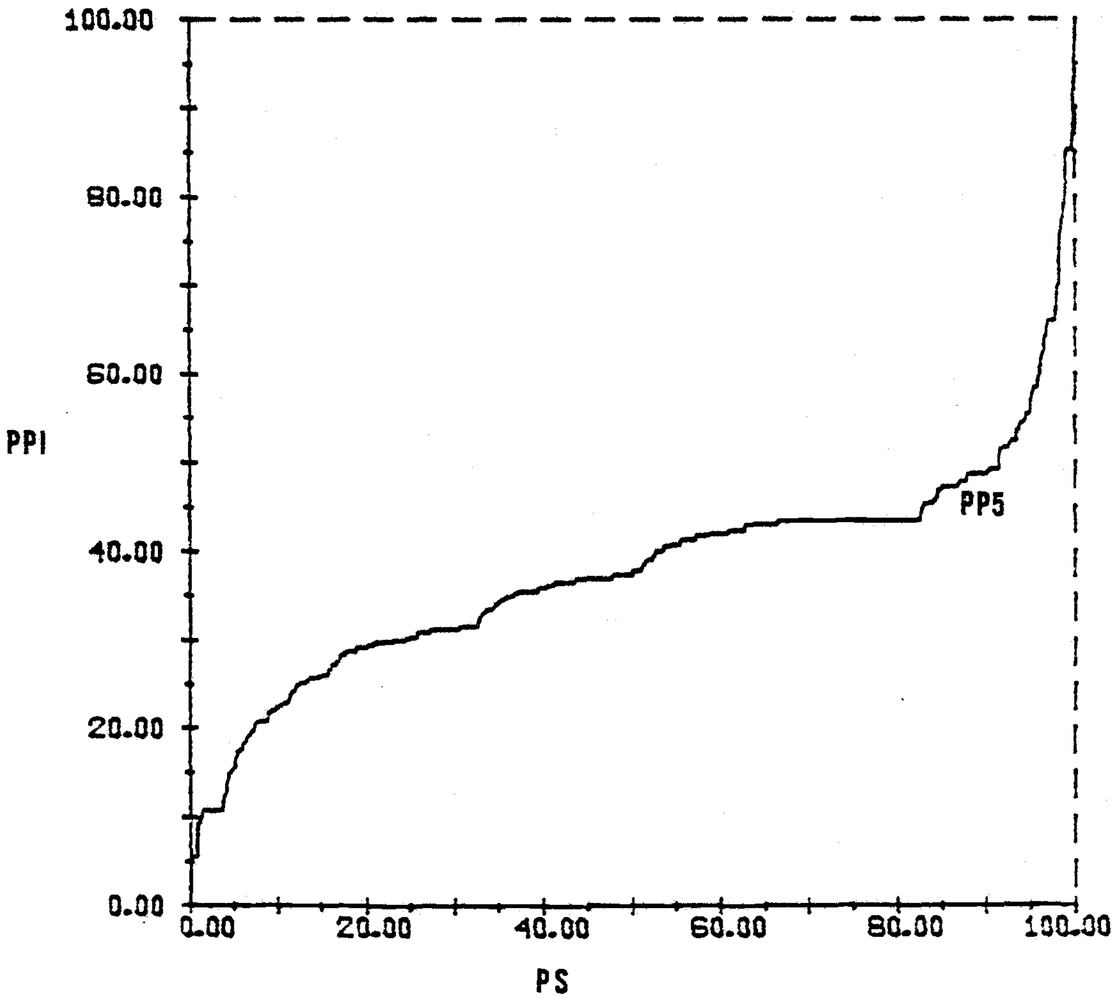

Figure 8. Public policy impact curve for allocation policy (5); 5_H, 5_I, 5_A, 80_{FW}, 5_E

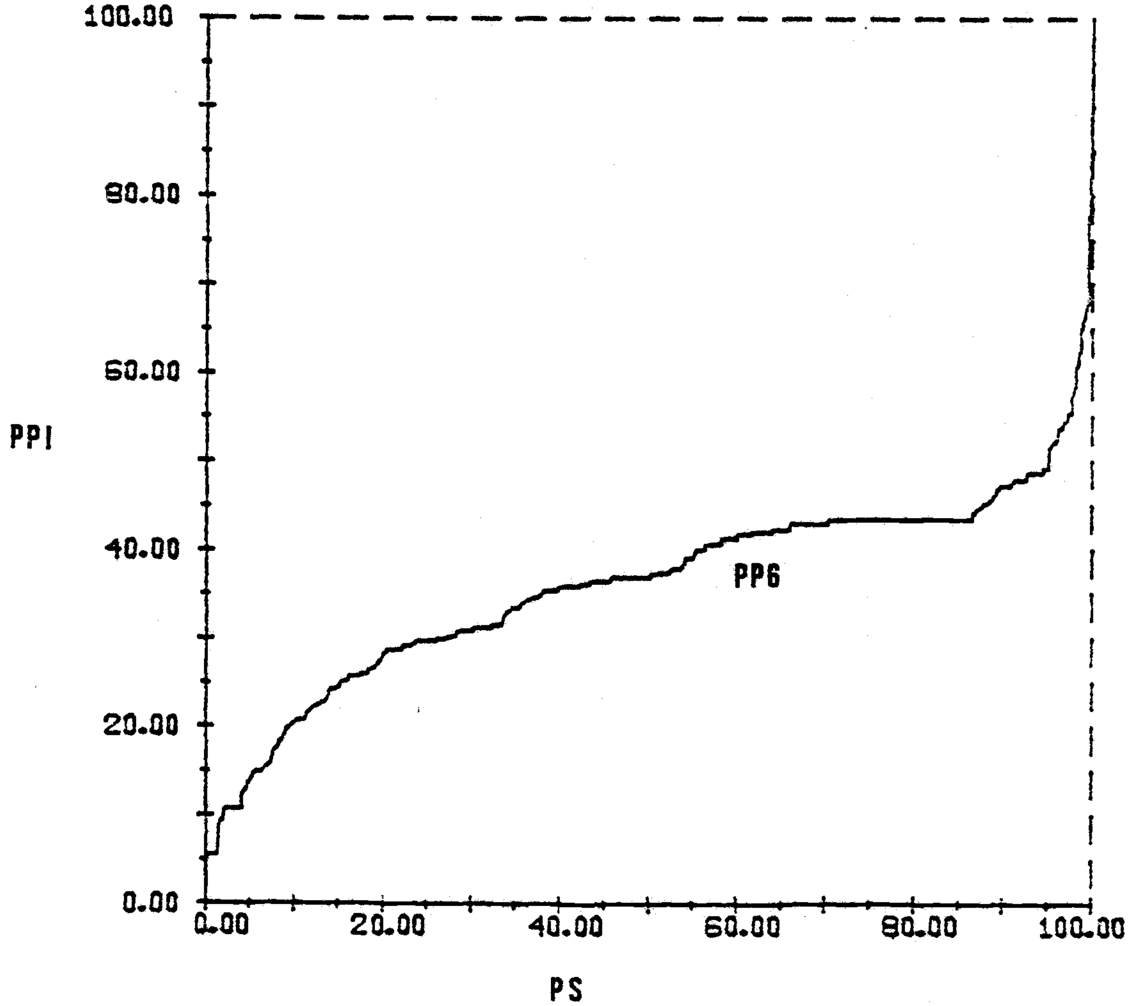

Figure 9. Public policy impact curve for allocation policy (6); 5_H, 5_I, 5_A, 5_{FW}, 80_E

fied with a policy that allocated most or all water to energy development, i.e., policy (6). It is interesting to note that, on the average, individuals gave energy development the least amount of water. Consequently, the population, as a whole, would be in a position to gain a greater percentage of their maximum satisfaction level if water was allocated to a use other than energy development.

The area under the PPI curves for policies (3), 3700.59, and (5), 3796.21, are not greatly different from one another. Hence, people would be similarly satisfied or dissatisfied, depending upon a policy maker's viewpoint, with implementation of either policy (3), which allocated 80 gallons to industry and jobs, or policy (5), which allocated 80 gallons for fish and wildlife habitat. Again, note that according to the average response (19_I and 17_{FW}), individuals did not give either use top priority in their allocations schemes.

If one calculates the mean allocation that all individuals made to each use (i.e., policy 7), food production (26 gallons) and household use (21 gallons) appeared to be of higher priority than other uses. When the two sub-optimal policies, weighting these uses heavily (policy (4), 80 gallons to food production, and policy (2), 80 gallons to household use), are examined, and the area under the PPI curves is calculated, policy (2) only equals 3921.57, while the corresponding area for policy (4) equals 4795.60. Therefore, it could be inferred that, given equal welfare weighting in this case, that policy (4) would dominate policy (2). This result follows from the mean responses for all uses (see Table 3), and determines, to some degree, the ranking of the sub-optimal policies in terms of social perferences.

Policy (7)'s, i.e., 21_H, 19_I, 26_A, 17_{FW}, 17_E (average response for the West), PPI curve is shown in Figure 10. The PPI curve is of similar shape to that for policy (1), although the area underneath (7)'s PPI curve is larger. Although the larger area indicates policy (7) is the better policy when compared to (1), there are a few interesting observations to note. The first percentile of respondents under policy (7) achieves approximately 19% of their maximum satisfaction level. Under policy (1), the "egalitarian" approach, the first percentile of respondents achieves approximately 22.5% of their maximum satisfaction level. The second percentile, or fraction of it, sees a large gain in the satisfaction level by immediately jumping to about 36% of the maximum. In contrast, the increase in percent satisfaction level for policy (7) is a little more gradual for the first few percentiles of the population.

Secondly, it can be seen by comparing Figures 4 (policy (1)) and 10 (policy (7)), that approximately 18% of the population has an allocation scheme which allows them to be completely satisfied, i.e., PPI = 100%, under policy (1). However, implementation of policy (7), would allow only the upper 1 or 1.5 population percentiles to enjoy maximum satisfaction.

Finally, note that between about the 3rd to 4th percentile and about the 82nd percentile, inclusively, all respondents achieved either the same percentage or higher, with policy (7), than with policy (1). Such an observation implies that an egalitarian approach to water allocation may help those individuals who are the "worst off" i.e., least satisfied, achieve a greater percentage of

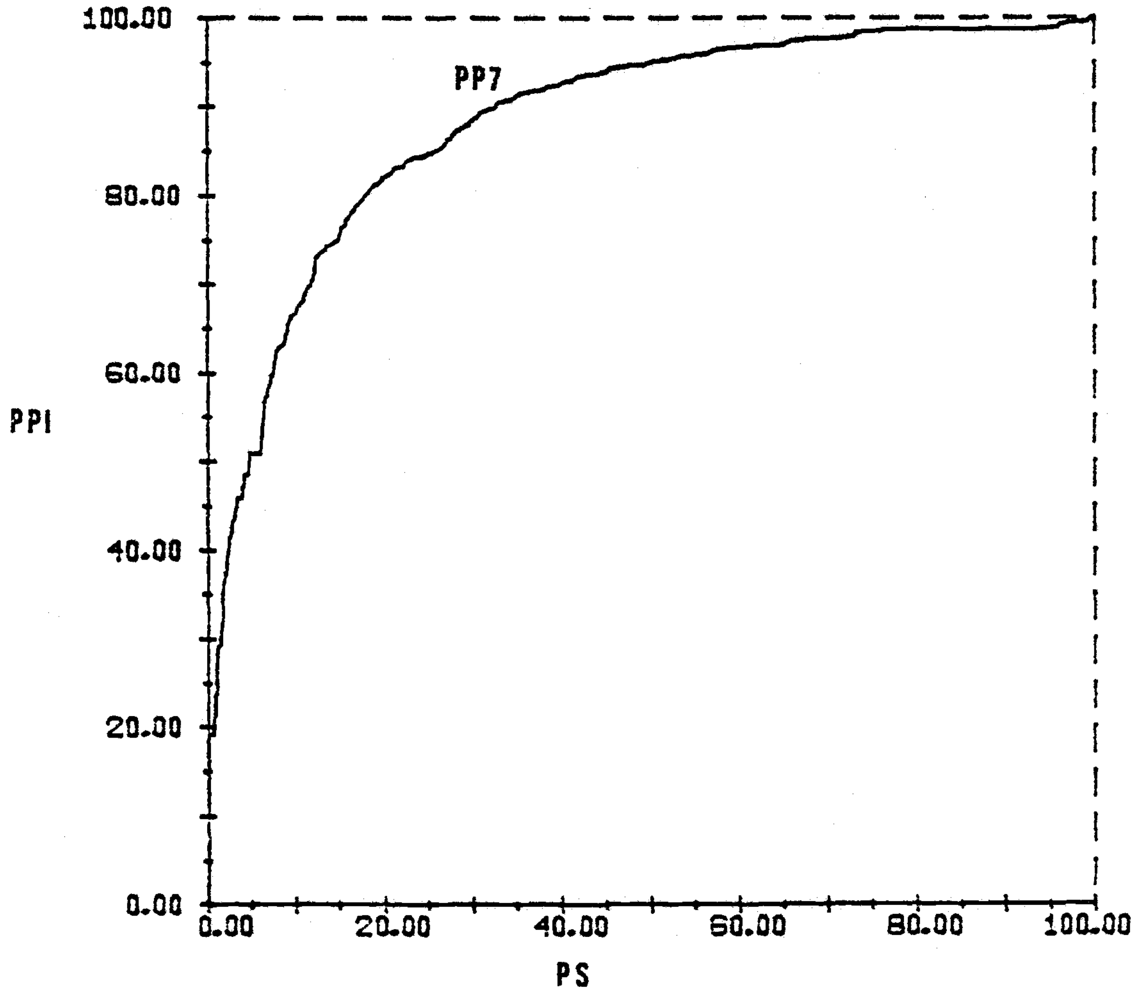

Figure 10. Public policy impact curve for allocation policy (7); 21_H, 19_I, 26_A, 17_{FW}, 17_E

their maximum satisfaction. The approach also helps the upper percentiles of the sample achieve their greatest percent of maximum satisfaction, i.e., 100%. Making both the lowest and highest sample percentiles "better off" places less importance on the well-being of individuals whose allocational preferences were not as extreme as those who were in the lowest and highest percentiles. Therefore, implementation of policy (7) would allow the sample, as a whole, to achieve a greater percentage of their maximum satisfaction level, while implementation of policy (1) would help those who were "worst off" achieve a higher percentage of their maximum satisfaction. The choice of policy (1), then, would imply a greater welfare weight given to the "most miserable" in society.

The PPI curves for policies (8), i.e., 4_H, 45_I, 3_A, 3_{FW}, 45_E, and (9), i.e., 45_H, 4_I, 45_A, 3_{FW}, 3_E, as shown in Figures 11 and 12, are similarly shaped to those curves for policies (2) through (6). As before, such PPI curves show that most people would not achieve a very high level of satisfaction, if either policy were to be implemented. With policy (8), only 9% of the population have an allocation scheme which allows them to achieve 50% or more of their maximum satisfaction level. The shape of and the relatively small area (3761.21) under the PPI curve for policy (8) can most likely be attributed to the fact that neither industry and jobs, nor energy development were favored uses for water allocation schemes. As a result, it could be expected that a policy, allocating most of the available water to two low priority uses, would not yield a particularly high level of satisfaction, for the overall population.

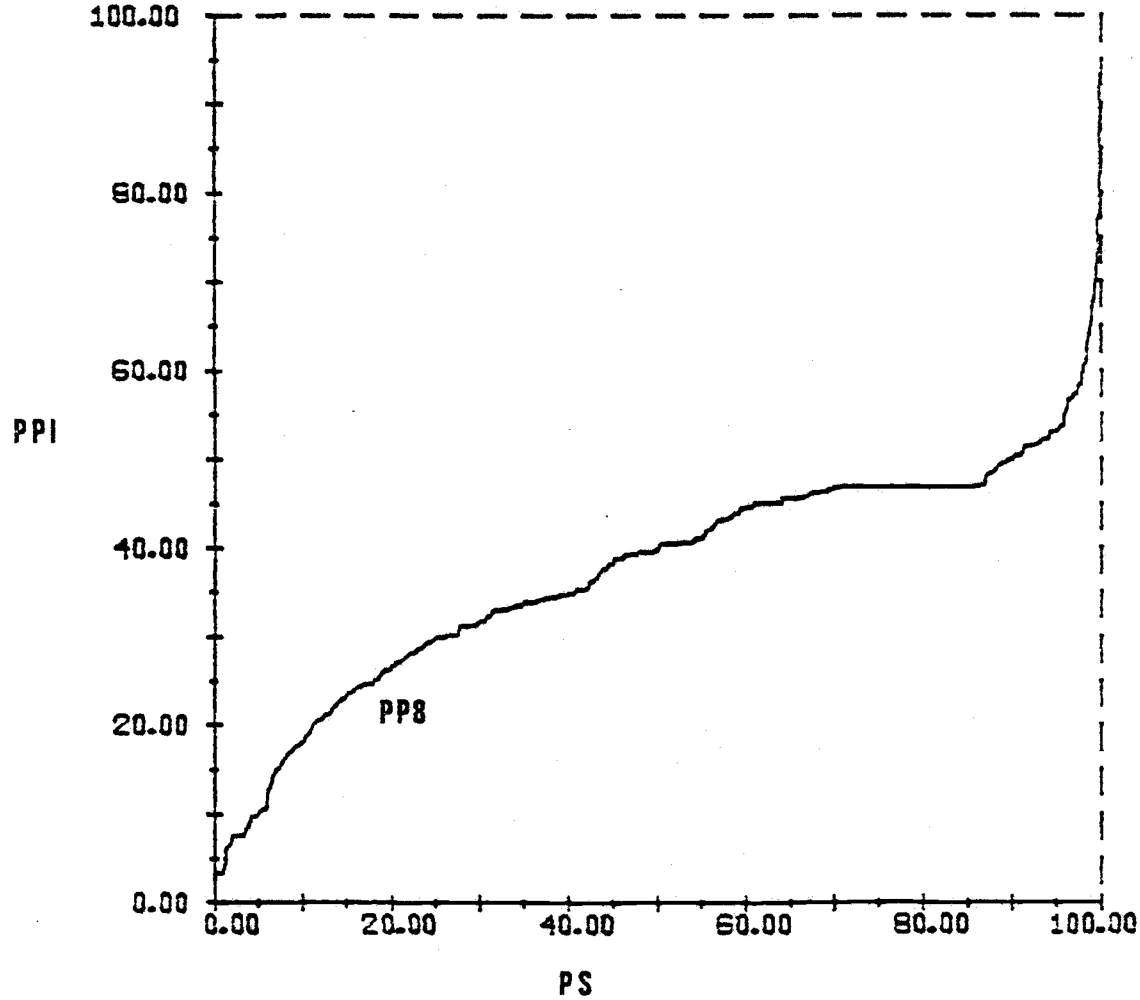

Figure 11. Public policy impact curve for allocation policy (8); 4_H, 45_I, 3_A, 3_{FW}, 45_E

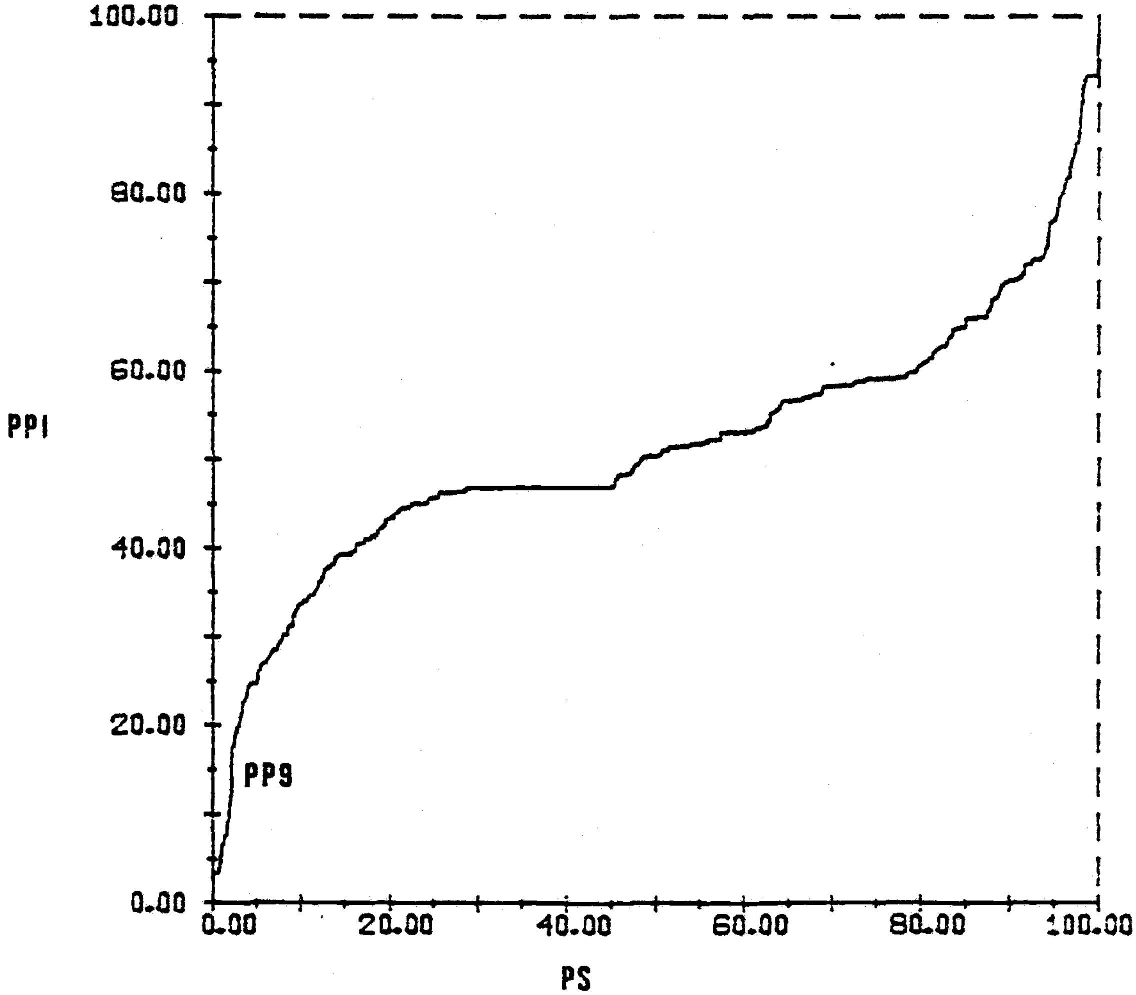

Figure 12. Public policy impact curve for allocation policy (9); 45_H, 4_I, 45_A, 3_{FW}, 3_E

Policy (9) fared better, in terms of the level of satisfaction attained for all respondents, than did policy (8), as indicated by the area, 5155.26, underneath the PPI curve. In fact, implementation of policy (9) would allow all respondents, as a group, to achieve a higher percentage of their maximum satisfaction than would implementation of the other policies listed, except for (1) and (7) (as shown by the areas in Table 3). Such a result could be expected, since water to household use and to food production were the most favored allocations. It is also interesting to note that policy (4), which allocates 80 gallons of water to food production, is the next policy, in descending order, that provides the most satisfaction to the entire sample. Hence, the allocation of water to the production of food appears to be a strong preference compared to others.

In summary, implementation of policy (7) would make society the "best off", as shown by the area, given in Table 3, under the PPI curve. Based on areas under associated PPI curves, in descending order from "best off" to "worst off", the policies are: (7), (1), (9), (4), (2), (5), (8), (3), and then, (6). However, it is necessary to remember from previous discussions, that the method is general and the policy ranking is valid only for the particular policies defined here, and only when the welfare weights are equal.

Discussion of the Survey Data

The water allocation question in the RCA Survey (see footnote 10) has some conceptual problems, which may have affected the way individuals responded. First, the current percentage of water (i.e., some unknown allocational policy) allocated to the various sectors, X_i, was not known to the individual. Had respondents known how water was allocated in their region, their stated preferences may have been different. For example, in Arizona, 95 percent of the total water supply is allocated to agriculture for irrigation purposes [Kelso et al. 1973], as it is for most states where irrigated agriculture is prevalent. Had respondents known that most water goes to agriculture, their responses may have been different.

Not only was the respondent uninformed with respect to the agricultural sector, but many individuals (if not most) would not have considered the dynamics involved when water is allocated to a sector. For example, water allocated to fish may only be considered in a dynamic framework, since the water level in one period affects fish population levels and their habitat in the next period. What the question seems to be asking indirectly, is "What social value do individuals place on fish and wildlife?" Perhaps a higher allocation of water to fish and wildlife habitat implies that an individual values highly the wildlife and the environment in which those animals live. If the question were to imply some rate of social value, then perhaps the question was written to determine the level at which people possess a conservation ethic (as stated in one of the purposes of the survey). Making these assumptions implies many things that were not asked. So, it may be best to simply say the question is too technical in nature for most lay people to understand. Yet, without the assumptions, the question may seem nonsensical to professional people.

Finally, the wording of the question is ambiguous with regard to water allocated to fish and wildlife. The respondent is told to assume all basic needs are met, but is then asked to allocate water to fish and wildlife habitat according to habitat needs. Additionally, the notion of meeting basic needs is unclear; does it mean that the respondent is to assume a subsistence level of water availability?

The way respondents allocated water could be, in many ways, a function of their knowledge of and experience with allocation processes, which could have been quite narrow without some study. For example, the importance of water in the agricultural sector or in the hydro power sector is clear to most people. However, it may not be so obvious how water would be used by industry, or by fish and wildlife, or how much water households, in the aggregate, actually use in comparison to agriculture and industry. These preconceptions, or lack of them, could influence the responses.

Given water is a scarce resource, a more appropriate approach to the question may have been to ask individuals their preferences for a decrease of 100 gallons. The responses would probably have been much different. Individual's attitudes toward natural resource conservation and management may have been more realistically reflected.

In addition to the above problems, there are problems with the way the question is designed. The order in which the sectors are listed affects individual's answers. Where the question is positioned within the entire survey also has an effect on how the individual will respond. Also, it can never be known if what a person says he/she prefers is the same as what would be done if the individual actually had 100 gallons of water to allocate among the sectors.

Finally, the regions in which responses were aggregated for this question do not appear to be homogeneous. Alaska, for example, has areas where; (1) annual rainfall is over 200 inches per year, (2) agricultural development projects have just begun, (3) there is great potential for hydro power, and (4) fish and wildlife resources are unsurpassed in quantity and quality. Living in such an environment would most likely have an affect upon individuals' responses. Yet, responses from Alaskan residents are mixed with responses from states, such as Arizona, which has an environment totally different from that found in Alaska. Thus, it might prove more interesting to look at public policy impacts in smaller areas, such as Alaska <u>or</u> Arizona. If this were to happen, definite regional preferences for certain types of allocations, besides those based on average responses, may be seen.

These latter problems exist within all surveys. These problems, in and of themselves, should not invalidate the survey question, which after all, was useful in couching the responses in a theoretical framework. The responses would then be used to derive the parameters of a form of utility function, appealing to the Weber-Fechner law and to utility maximizing behavior.

The data obtained from the question are, therefore, still useful, even after considering the associated problems. If analyzed with proper reservation, much information may be obtained from the question. Although the question is not perfectly designed, it represents an effort to obtain public preferences for water allocation. Since water allocation is politically determined, information about the public's preferences may be useful.

Discussion of the Methodology

Much has been discussed in the previous section of the problems associated with the survey question and the information obtained from it. In a large part, the use of "public policy impact analysis", as described previously, has helped to gain more information from the data despite the several theoretical and technical short-comings, described above. In this respect, the public policy impact methodology is very useful.

However, there are two problems associated with public policy impact methodology, which should be noted. One of these problems is the difficulty involved in empirically testing the existence and robustness of the β_is in this study. Previous researchers [Stevens, 1966] have been able to make use of the method of "cross modality matching", which consists of equating two different subjective responses to two different stimuli; say perceptions of noise and vibration, where the functional relationship of one stimulus/response is known with some certainty[13].

13/ Suppose, according to Stevens [1966] that there exists two stimulus/response functions, $\psi_1=k_1\phi_1^{\beta_1}$; $\psi_2=k_2\phi_2^{\beta_2}$. If, experimentally, the 2 responses can be matched, then $k_1\phi_1^{\beta_1}=k_2\phi_2^{\beta_2}$. Taking the log of both sides and solving for $\ln\phi_1$, will give a straight line with a slope of β_2/β_1. If either parameter is known, then the other can be determined. In practice, data is recorded for each stimulus, transformed to logs and plotted against each other; the slope of which is the ratio of the 2 parameters in the stimulus/response functions.

Another difficulty is the importance of welfare weightings on the choice of policies. Although, it is next to impossible for economic researchers to make meaningful welfare statements, the application of welfare weights to policy issues is very common. It is necessary, then, to explicitly define a welfare weighting; if for no other purpose than to begin the analysis. The weighting of responses by peripheral political and social information has been traditionally dealt to decision makers; yet, the process of assigning weights may be very complex.

The public policy impact method will generally provide a low cost and easily interpreted method for comparing a limited number of policy alternatives. However, this very feature may preclude discovery of the best policy. Choosing to find the policy that would maximize aggregate satisfaction, subject to all individual specifications of all power functions, could be an option.

The analysis used in this study is very consumer oriented, and there has been no indication that different costs are attached to different policies. Hence, there has been an implicit assumption that all policies are equally feasible in every respect, and that consumer preferences have priority over all other considerations.

It also seems obvious that large regional break-downs tend to strongly affect the policy outcomes from this model. As discussed in the previous section, the policy outcome from this study most likely cannot be applied to sub-divisions of the Western region. The policy prescription calls for allocations based on the average of preferences or on equal distributions among all uses. Such a prescription is entirely appropriate considering the enormous land mass, diversity of climate and of people. However, the prescription should only be used to guide policy for the whole Western region. So, in future data collection efforts, it would be wise if the relevant data were collected in a manner that would allow researchers to examine potential impacts in smaller regions. If such data collection could be done, then effects of an allocation policy, where the physical result of that policy (for example, a dam or a wildlife refuge) has an impact upon the population and/or environment could be investigated.

Suggestions for Future Research

The discussions of the previous two sections have revealed some areas that might bear further exploration:

(1) The appeal of this method could be greatly enhanced if empirical testing procedures, such as cross-modality matching, could be devised for the use of the power function.

(2) Similar studies should be performed in regional areas, possibly on state-wide bases, or for areas that might directly feel the impacts of a specific project resulting from a policy.

(3) Considerable ambiguity in the question, interpreted by the respondents, may be eliminated by wording similar questions in a way that would avoid the problems, discussed in the earlier section criticizing the data.

This methodology, applied to similar problems involving allocation of scarce public goods could prove useful at making meaningful comparisons between different well-defined policies based on perceptions of an informed public.

BIBLIOGRAPHY

Alexander, Sidney S. "Price Movements in Speculative Markets: Trends or Random Walks," *Industrial Management Review*, v.2 (May) 1961. 7-26.

Anderson, Jock R., John L. Dillon, and J. Brian Hardaker. *Agricultural Decision Analysis*. The Iowa State University Press, Ames, Iowa. 1977.

Arrow, Kenneth J. "Exposition of the Theory of Choice Under Uncertainty," in *Essays in the Theory of Risk-Bearing*. North-Holland, Amsterdam. 1970.

Arthur, Louise M. "Quantifying Socio-Environmental Impacts of Predator Control Policies," *Social Indicators Research*, v.5 1978. 235-244.

Arthur, Louise M. *Measuring Public Attitudes Toward Natural Resource Issues: Coyote Control*. Natural Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Technical Bulletin No. 1657. July, 1981.

Baumol, Willaim J. *Economic Theory and Operations Analysis*, 4th ed. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1977.

Bell, David E., Ralph L. Keeney, and Howard Raiffa, Eds. *Conflicting Objectives in Decisions*. John Wiley and Sons, Inc., New York. 1977.

Bell, David E. *Defining and Quantifying Goals for Measuring the State of an Ecosystem*. International Institute for Applied Systems Analysis, Schloss Laxenburg. 1974.

Breault, K. "Modern Psychophysical Measurement of Marginal Utility: A Return to Introspective Cardinality?" *Social Science Quarterly*, v. 62(Dec.) 1981. 672-684.

Deaton, Angus and John Muellbauer. *Economics and Consumer Behavior*. Cambridge University Press, Cambridge. 1980.

DeGroot, M. H. *Optimal Statistical Decisions*. McGraw-Hill, Inc., New York. 1970.

Dillon, John L. "An Expository Review of Bernoullian Decision Theory in Agriculture: Is Utility Futility?" *Review of Marketing and Agricultural Economics*, v. 39(1) 1971. 3-80.

Doerksen, Harvey R. and John C. Pierce. "Citizen Influence in Water Policy Decisions: Context, Constraints, and Alternatives," in *Water Politics and Public Involvement*. John C. Pierce and Harvey R. Doerksen, Eds. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan. 1976.

Downs, A. *Inside Bureaucracy*. Little, Brown and Company, Boston, Mass. 1967.

Dréze, J. H. "Axiomatic Theories of Choice, Cardinal Utility and Subjective Probabilities: A Review," in *Allocation Under Uncertainty: Equilibrium and Optimality*. Macmillan and Co., Ltd., New York. 1974.

Eckman, G. "Discriminal Sensitivity on the Subjective Continuum," *Acta Psychology*, v. 12, 1956. 233-243.

Eckman, G. "Weber's Law and Related Functions," *Journal of Psychology*, v. 47, 1959. 343-352.

Eckman, G. and T. Kunnapas. "Measurement of Aesthetic Value by "Direct" and "Indirect" Methods," *Scandinavian Journal of Psychology*, v. 3, 1962. 33-38.

Eckstein, Otto. *Water Resource Development: The Economics of Project Evaluation*. Harvard University Press, Cambridge, Mass. 1958.

Edgeworth, Francis Y. *Mathematical Physics*. Kegan Paul and Co., London. 1881.

Edwards, George C., III and Ira Sharkansky. *The Policy Predicament: Making and Implementing Public Policy*. W. H. Freeman and Co., San Francisco. 1978.

Fechner, G. T. *Kollecktivnasslehre*. (As abstracted by Schumpeter [1954]) 1897.

Fischer, Gregory W. "Utility Models for Multiple Objective Decisions: Do They Accurately Represent Human Preferences?" *Decision Sciences*, v. 10, 1979. 451-479.

Fisher, Victor, John Boyle, Mark Schulman, and Michael Bucuvalas. *A Survey of the Public's Attitudes Toward Soil, Water, and Revewable Resources Conservation Policy*. Study No. 792802, Louis Harris and Associates, Inc., Washington, D.C. Dec. 1979.

Galanter, Eugene. "The Direct Measurement of Utility and Subjective Probability," *American Journal of Psychology*, v. 75(Dec) 1962. 208-220.

Galanter, Eugene. "Psychological Decision Mechanisms and Perception," in E. C. Carterette and M. P. Friedman, Eds., *Handbook of Perception, Vol. 2, Psychological Judgement and Measurement*. New York Academic Press, New York. 1974.

Galanter, Eugene and Paul Pliner. "Cross-Modality Matching of Money Against Other Continua," in H. Moskowitz, et al. Eds., *Sensation and Measurement: Papers in Honor of S. S. Stevens.* Dordrecht Reidel. 1974.

Galanter, Eugene. *Utility Scales of Monetary and Non-Monetary Events.* Columbia University Psychophysics Laboratory, New York. 1975.

Gossen Hermann H. *Development of the Laws of Exchange Among Men.* Springer-Verlag, Berlin. 1854.

Gum, Russell L. "Including Aesthetic Considerations in Environmental Planning," Photocopy of Manuscript, (1973). 15p.

Gum, Russell L., Theordore G. Roefs, and Dan B. Kimball. "Quantifying Societal Goals: Development of a Weighting Methodology," *Water Resources Research,* v. 12(4) 1976. 617-622.

Gum, Russell L., et al. *Quantified Evaluation for Decisions: Measuring Achievement of Environmental Goals and Analyzing Trade-Offs.* Tech. Bull. 145, Oregon State University Agr. Exp. Sta., Corvallis, Oregon. Nov. 1982.

Guralnik, David B., Ed. *Webster's New World Dictionary of the American Language,* 2nd College Edition. William Collins and World Publishing Co., Inc. 1978.

Hamblin, Robert L. and Carole R. Smith. "Values, Status, and Professors," *Sociometry,* v. 29(3) 1966. 183-196.

Hamblin, Robert L. "Mathematical Experimentation and Sociological Theory: A Critical Analysis," *Sociometry,* v. 34(4) 1971. 423-452.

Hamblin, Robert L., Donald H. Clairmont, and Bruce A. Chadwick. "Utility and Gambling Decisions: Experiments and Equations," *Social Science Research,* v. 4, 1975. 1-15.

Hicks, J. R. and R. G. D. Allen. "A Reconsideration of the Theory of Value," *Economica,* Part I: v. 1(Feb.) 1934. 52-75; Part II: v. 1 (May) 1934. 196-219.

Hicks, J. R. *Value and Capital: An Inquiry into Some Fundamental Principles of Economic Theory,* 2nd ed. Oxford University Press, London. 1946.

Hirshliefer, Jack, James C. DeHaven, and Jerome W. Milliman. *Water Supply: Economics, Technology, and Policy.* University of Chicago Press, Chicago, Illinois. 1960.

Hotelling, H. S. "Demand Functions with Limited Budgets," *Econometrica*, v. 3, 1935. 66-78.

Houthakker, H. S. "Revealed Preference and the Utility Function," *Economica*, v. 17(May) 1950. 159-174.

Jevons, W. Stanley. *The Theory of Political Economy*, 4th ed. MacMillan and Co., Ltd., London. 1924.

Judge, R. W. "Cognitive Strawman: Public Input to a Water Resource Planning System," Ph.D. Dissertation, Dept. of Hydrology and Water Resources, Univ. of Arizona, Tucson.

Keeney, Ralph L. *Multiattribute Utility Analysis: A Brief Survey.* International Institute for Applied Systems Analysis, Laxenburg, Austria. RM-75-43. August 1975.

Keeney, Ralph L. *Preference Models of Environmental Impacts.* International Institute for Applied Systems Analysis, Laxenburg, Austria. RM-76-4. January 1976.

Keeney, Ralph L. and Howard Raiffa. *Decisions With Multiple Objectives: Preferences and Value Tradeoffs.* John Wiley and Sons, Inc., New York. 1976.

Kelso, Maurice M. "The Water-Is-Different Syndrome or What Is Wrong With the Water Industry?" *Proceedings of the 3rd Annual American Water Resources Conference*, Nov. 8-10, 1967. 176-183.

Knight, Frank H. *Risk, Uncertainty, and Profit.* Houghton Mifflin Co., Boston, Mass. 1921.

Knox, Paul L. "Subjective Social Indicators and Urban Social Policy: A Review," *Policy and Politics*, v. 7(3) 1979. 299-309.

Marshall, Alfred. *Principles of Economics: An Introductory Volume*, 8th ed. MacMillan and Co., Ltd., London. 1922.

Mazmanian, Daniel A. "Participating Democracy in a Federal Agency," in *Water Politics and Public Involvement.* J. C. Pierce and H. R. Doerksen, Eds., Ann Arbor Science Publishers, Inc., Ann Arbor, Mich. 1976.

Mazmanian, Daniel A. and Jeanne Nienaber. "Prospects for Public Participation in Federal Agencies: The Case of the Army Corps of Engineers," in *Water Politics and Public Involvement.* J. C. Pierce and H. R. Doerksen, Eds., Ann Arbor Science Publishers, Inc., Ann Arbor, Mich. 1976.

McKenzie, L. W. "Demand Theory without a Utility Index," *Review of Economic Studies*, v. 24(65) 1956-7. 185-189.

Menger, Carl. *Principles of Economics, First, General Part.* J. Dingwall and B. F. Hoselitz, Tr. & Eds., The Free Press, Glencoe, Illinois. 1950.

Metfessel, Milton. "A Proposal for Quantitative Reporting of Comparative Judgements," *Journal of Psychology*, v. 24, 1947. 229-235.

Osborne, M. F. M. "Brownian Motion in the Stock Market," *Operations Research*, v. 7(March-April) 1959. 143-173.

Pareto, Vilfredo F. D. *Manuel d'Economie Politique.* (as abstracted by Hicks [1946]. 1909.

Raiffa, Howard. *Decision Analysis: Introductory Lectures on Choices Under Uncertainty.* Addison-Wesley, Reading, Mass. 1968.

Ramsey, F. P. "Truth and Probability," in *The Foundations of Mathematics and Other Logical Essays.* Paul, Trench, Trubner Publishers, London. 1931.

Rausser, Gordon C. and Joseph Yassour. "Multiattribute Utility Analysis: The Case of Filipino Rice Policy," *American Journal of Agricultural Economics*, v. 63(3) 1981. 484-494.

Samuelson, Paul A. "A Note on the Pure Theory of Consumer Behavior," *Economica*, v. 5(Feb.) 1938. 61-71.

Samuelson, Paul A. *Foundations of Economic Analysis.* Harvard University Press, Cambridge, Mass. 1947.

Savage, L. J. *The Foundations of Statistics.* Wiley and Sons, New York. 1954.

Schumpeter, Joseph A. *History of Economic Analysis.* Oxford University Press, New York. 1954.

Slutsky, Eugen. "Sulia teoria del bilancio des consomatore," *Giornale degli Economisti*, v. 51, 1915. 1-26. English trans. in *Readings in Price Theory.* G. J. Stigler and K. E. Boulding, Eds., Chicago University Press. 1952.

Stark, W., Ed. "The Philosophy of Economic Science," in *Jeremy Bentham's Economic Writings, Volume 1.* George Allen and Unwin, Ltd., London. 1952.

Stevens, S. S. "On the Brightness of Lights and the Loudness of Sounds," *Science*, v. 118(Nov.) 1953. 576- ? .

Stevens, S. S. "On the Psychophysical Law," *Psychology Review*, v. 64, 1957. 153-181.

Stevens, S. S. "Measurement, Psychophysics, and Utility," in *Measurement: Definitions and Theories*. C. W. Churchman and P. Ratoosh, Eds., Wiley and Sons, Inc., New York. 1959.

Stevens, S. S. "The Surprising Simplicity of Sensory Metrics," *American Psychology*, v. 17. 1962. 29-39.

Stevens, S. S. "A Metric for the Social Consensus," *Science*, v. 151(4) 1966. 530-541.

Stevens, S. S. "Sensory Scales of Taste Intensity," *Perception and Psychophysics*, v. 6(5) 1969. 302-310.

Stigler, George. "The Development of Utility Theory," *Journal of Political Economy*, v. 58, 1950. 307-396.

Thurstone, L. L. "Psychophysical Analysis," *American Journal of Psychology*, v. 38, 1927. 368-389.

Thurstone, L. L. *The Measurement of Values*. University of Chicago Press, Chicago, Illinois. 1959.

U. S. Department of Agriculture. "Public Attitudes Revealed on Soil and Water Conservation," *News*, USDA 151-80. Jan. 17, 1980.

U. S. Department of Agriculture. *Soil, Water, and Related Resources in the United States: Status, Conditions, and Trends; 1980 Appraisal Part I*. March 1981.

U. S. Department of Agriculture. *Soil, Water, and Related Resources in the United States: Analysis of Resource Trends; 1980 Appraisal Part II*. March 1981.

Von Neumann, John and Oskar Morgenstern. *Theory of Games and Economic Behavior*, 2nd ed. Princeton University Press, Princeton, New Jersey. 1947.

Walras, Léon. *Elements of Pure Economics; or The Theory of Social Wealth*. Trans. by W. Jaffé. Richard D. Irwin, Inc., Homewood, Illinois. 1954.

Weber, Max. "Marginal Utility Theory and "The Fundamental Law of Psychophysics"," *Social Science Quarterly*, v. 56(June) 1975. 21-36.