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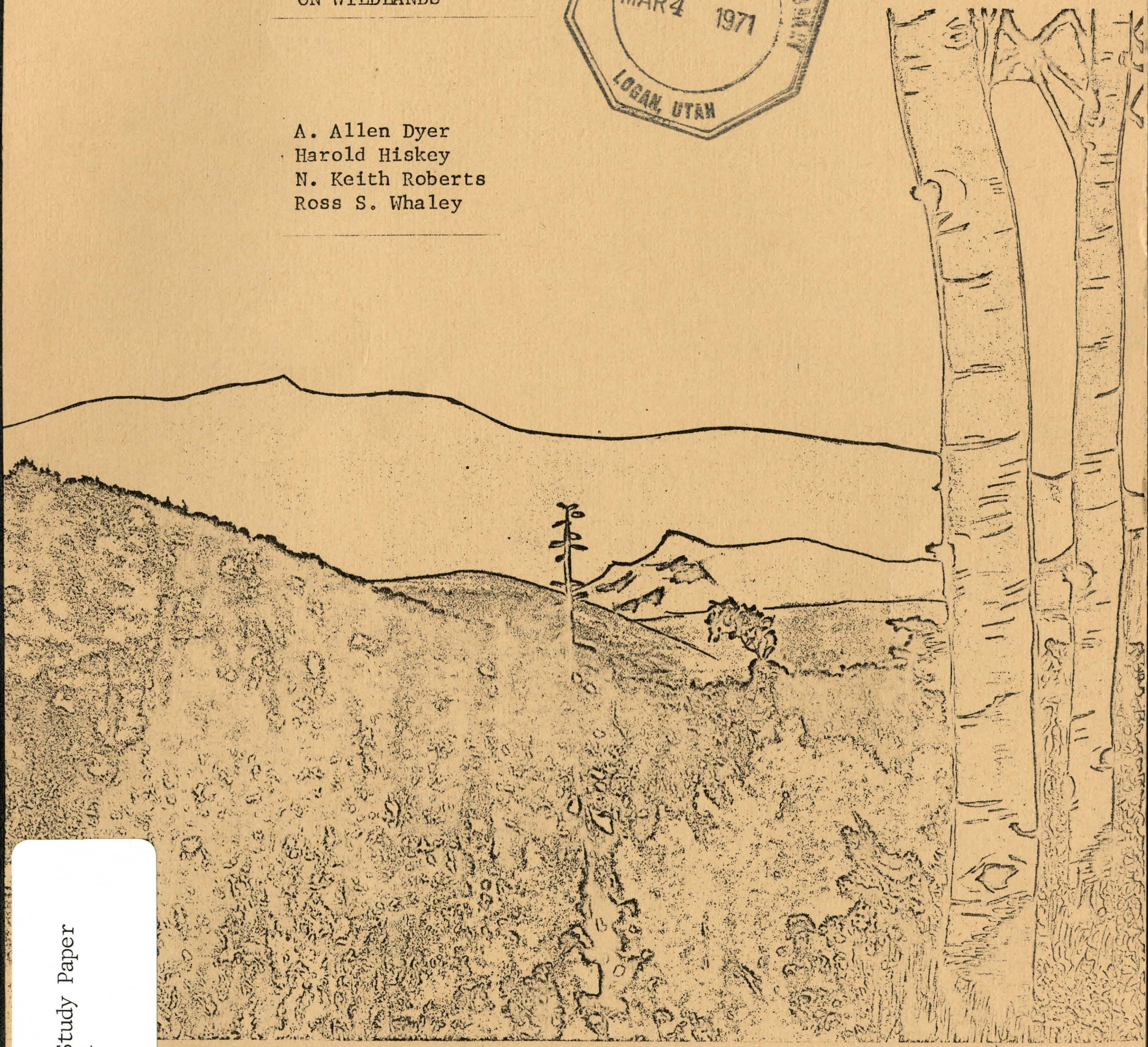

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INTRODUCATION

This report presents the results of a project conducted for the Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service. This study entitled "Natural Resource valuation - the conceptual and operational basis for economic analysis in a multiple use context" had two objectives:

1) To develop concepts and procedures for determining comparable values of natural resources used in production of goods and services that move through markets. Comparability must be in terms of (a) theoretical framework and (b) stage of production and distribution process.

2) To develop concepts and procedures for determining comparable values of natural resources used in production of goods and services that do not move through markets. Comparability must be in terms of (a) theoretical framework and (b) stage of production and distribution process.

While conducting this study we operated on several assumptions basic to the analysis. (1) The decision-making agencies represent society's desire to produce goods and services on public resourcess--the supply side. (2) The users represent society's desire to consume goods and services produced on public resources--the demand side. (3) Apparent historical deviations from the above stated assumptions are short-run aberrations resulting from grossly imperfect knowledge about the physical and economic relations that exist among public resource users and uses. (4) Economics can do two things for those making decisions about how public resources will be used: (a) determine the allocation that will maximize economic benefits and (b) determine economic costs resulting from deviations from the maximizing solution.

GENERAL PROBLEMS ASSOCIATED WITH ALLOCATION DECISIONS FOR FOREST LANDS

Investments in various forest management alternatives have characteristically been made with little attention to refined economic analysis of the returns from different projects. This is particularly true of forest management investments on public lands.

Several reasons can be cited why little concern has been given previously to determining investment priorities by public forest management agencies. First, most public resource management has been on a rather extensive basis requiring little new investment. For example, improvement of existing forest stands was usually done in conjunction with timber sales. The small net investment associated with this type of management was the opportunity cost resulting from adjusting cutting practices to improve residual stands or aid regeneration rather than obtaining maximum immediate return. Secondly, the investments in management that did occur were dictated by policy originating from considerations other than economic. Fire control, insect and disease control, and planting were performed because they were thought good conservation measures, not necessarily because they were sound investments.[1] Also competition within forest administration agencies for funds for non-timber uses was not as keen as it is today. Now timber growing must compete with many other uses of the forest and for investment funds which must be shared with these other uses.

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[1] Whaley, Ross Samuel. 1968. Economic Guidelines for Timber Management Investments in Michigan. Ph.D. Dissertation, The University of Michigan.

Changes within the economic environment within which decisions must be made have increased the importance of carefully weighing investment choices. As management becomes more intensive, each additional practice yields a lower marginal net return, and the difference in rates of return between alternatives is likely to become less obvious from cursory examination. Public investment decisions based on rules-of-thumb or informal analysis are no longer adequate.

<u>Resource Allocation in the Competitive Market</u>

A central concept of economics in the capitalisitc world is that the price system, operating through the market place, balances supply and demand and most efficiently allocates scarce resources among competing uses. This results from a series of relationships between producers and consumers. These relationships are illustrated in Figures 1 and 2.

Figure 1 simply illustrates that in the conceptual market relationships, firms operate to maximize profits. They do this by certain behavior in the market for the factors of production and in the market for the products they produce. Similarly consumers enter the goods market and make decisions about the purchase of goods and enter the factors market and sell their own resources. These decisions are made so as to maximize their well-off-ness or utility.

Figure 2 illustrates in a little more detail the behavior which will accomplish the goals of producers and consumers. It is recognized, of course, that the simplified system illustrated in the two figures only gives an optimum allocation of resources if certain exogenous conditions are met. It is also recognized that the goal of profit maximization can be questioned. Yet despite these considerations this simplified model does give (1) a first approximation of the resource allocation process in the market and (2) some insight into the nature of price determination and the relationship between "price" and "value." That is, price is an equilibrating point which at once represents the "value" to the consumer of the marginal good sold and the "value" to the producer of the marginal good produced.

It is this insight into the relationship between price and value that these diagrams are useful to our discussion of the problem of resource allocation or investment decision making in the public sector. The public land management agencies are producers that need some index of value to allow them to make decisions.

<u>Uniqueness of resource allocation on public lands</u>[1]

Problems of allocating resources (on public forest lands) are of special interest because of the fact that many of the products produced have not traditionally been sold in the market place, and thus we have no index of value similar to that generated by the market system. The goods produced on public lands often have not been sold because of a certain "publicness" associated with these products.

Let's first examine the "publicness" of some goods and services. It is recognized that the market system does not result in an optimum allocation of resources in all instances.[2] We, as a body politic, have decided that many natural resources fall into the category of an exception and have re-

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[1] Much of the material in the introductory statement was also reported in an article "Multiple Use Decision Making--Where Do We Go From Here?" Submitted to the Natural Resources Journal.

[2] The kinds of decisions that are most efficiently handled by either the market system, the political system, or some central agency are not easily delineated. This issue represents a major difference between capitalism, socialism, and marxism.

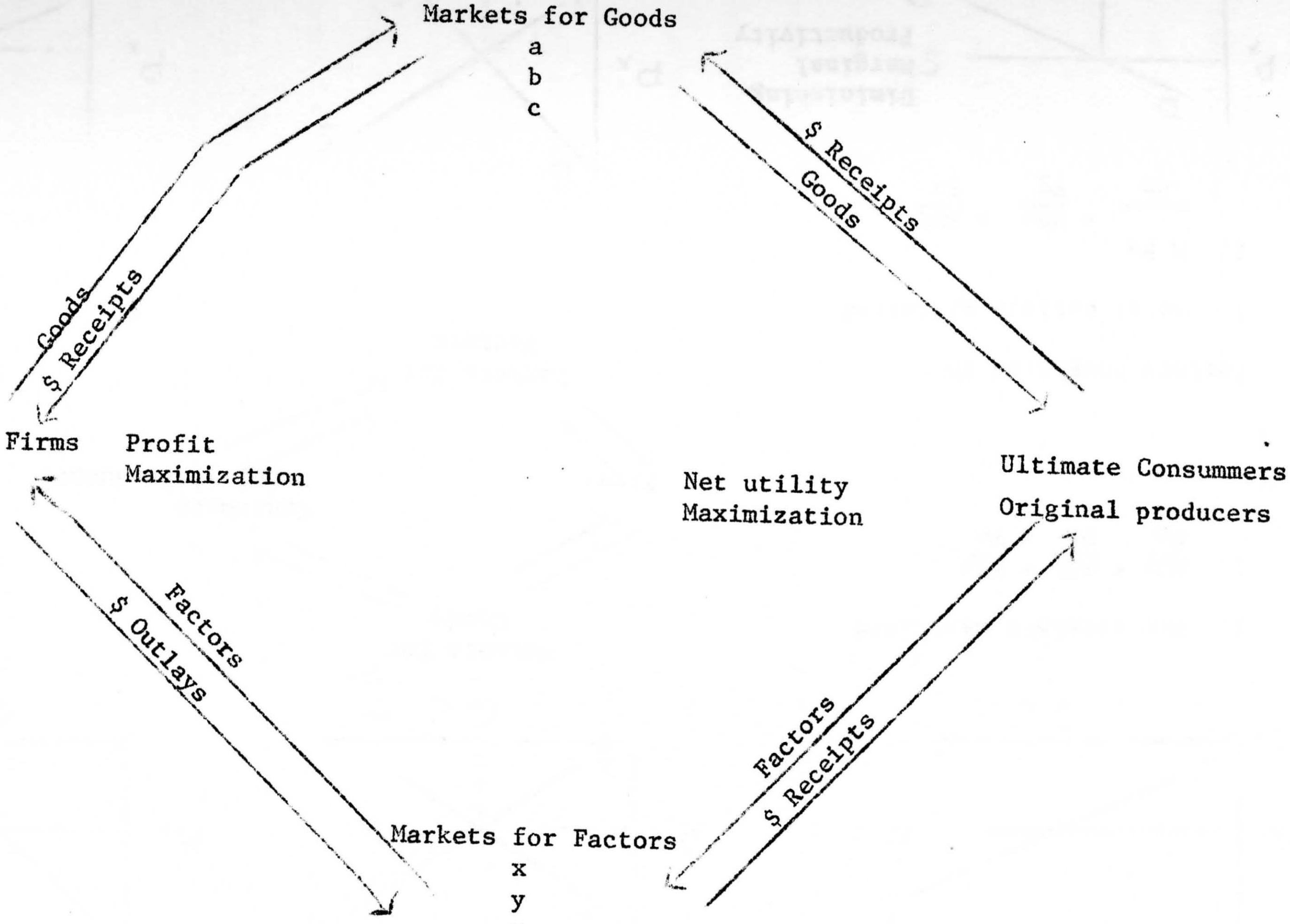
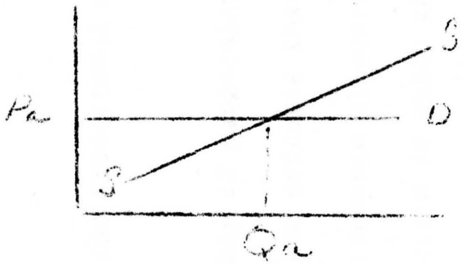

Markets for Goods
a
b
c
$ Receipts
Goods
Goods
$ Receipts
Firms
Profit
Maximization
Net utility
Maximization
Ultimate Consummers
Original producers
Factors
$ Outlays
Factors
$ Receipts
Markets for Factors
x
y
z

Figure 1.

For one firm and one good



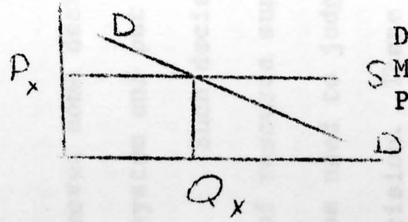
1. Net receipts maximized

2. $\frac{MCa}{Pa} = \frac{MCb}{Pb} = \frac{MCc}{Pc}$

Factors bought so that

1. Total outlays minimized

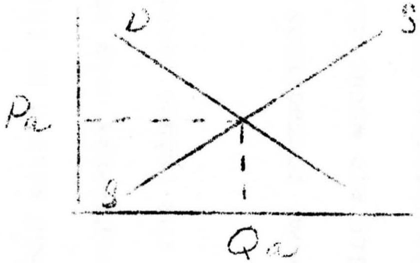
2. $\frac{MPx}{Px} = \frac{MPy}{Py} = \frac{MPz}{Pz}$

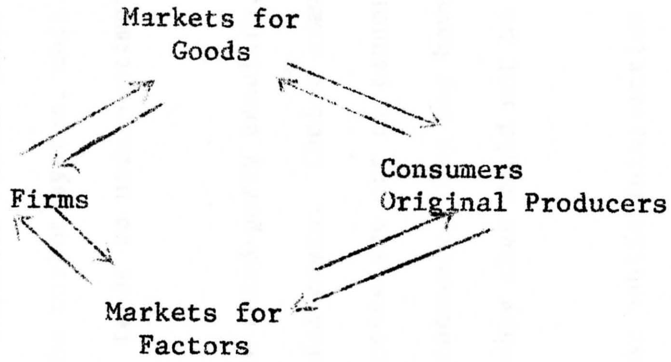


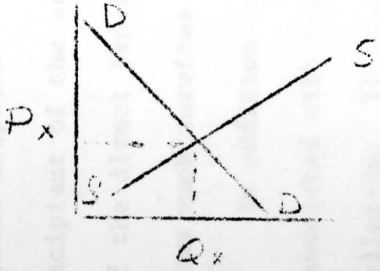
Diminishing Marginal Productivity

For one firm and one factor

For each Good

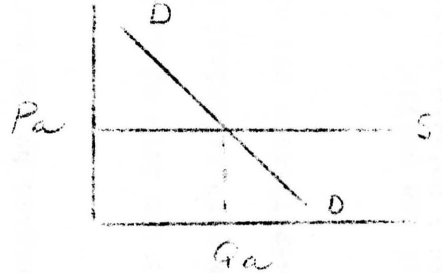






For each factor

For one customer and one good



Diminishing Marginal Utility

Goods Bought so that

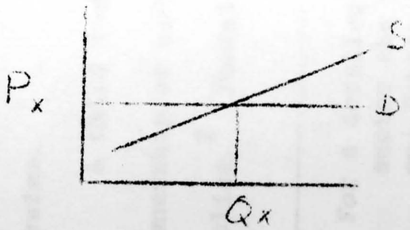
1. Total Utility Maximized

2. $\frac{MUa}{Pa} = \frac{MUb}{Pb} = \frac{MUc}{Pc}$

Factors sold so that

1. Total disutility minimized

2. $\frac{MDx}{Px} = \frac{MDy}{Py} = \frac{MDz}{Pz}$



Increasing Marginal Disutility

For one seller and one factor

Figure 2.

moved some decisions regarding these resources from the traditional market system and put them under public control.

Such decisions, for public regulation or ownership of particular kinds of resource supplies, need not be arbitrary. There are criteria that may be used to judge the legitimate "publicness" of any resource allocation decision. These criteria are associated with the instances in which the market system does not give the most efficient allocation of resources.[1]

One of these instances occurs in conjunction with substantial third party benefits. That is, some goods and services such as education, defense, mental hospitals, etc. offer benefits beyond those that accure to the direct recipient of the service. The market system, which expresses only the demand of the direct beneficiaries, tends to under-estimate the values received from such services.

In addition to the above third-party benefits, some commodities are associated with indirect social costs. Choice examples are water and air pollution. If these social costs are not or cannot be absorbed by the producer of the good or its consumer, they may have no influence on the price of the commodity, and they then would not be weighed by the market system.

A third justification for public intervention in the form of either ownership or control of production enterprises occurs with technical monopolies.[2] Postal service, telephone service, and transportation are classi-

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1 For a detailed discussion of the appropriate role of the public sector the reader should see Edmund S. Phelps (Ed.) Private Wants and Public Needs. W. W. Worton & Company Inc.; particularly Walter W. Heller's article, "Reflections on Public Expenditure Theory."

2 See Milton Friedman, "The Role of Government in a Free Society," in Phelps, Private Wants and Public Needs.

fied by some economists as technological monopolies. In a technological monopoly, government may have to subsidize production of the commodity to insure a supply at a price that meets the demands of society.

Lastly, government intervention in the market system is often considered justified on the basis of substantial differences between the time preference of society as a whole and an individual's time preferences. This justification rests largely on the greater ability of government to absorb uncertainty in investments in such things as basic research. Elements of several of the above considerations are relevant to the supply of multiple products from the nation's forest lands. For example, the conservation issue involves the consumption of limited resources over time. It is argued that the time preference of individuals is too limited to adequately weigh the intertemporal value of resources, the use of which straddles several generations.

It can also be argued that substantial third party benefits result from the production of water and recreation on forest lands.

This paper, however, argues neither for nor against government ownership of vast acreages of forest land. Rather, its purpose is to point out the resource allocation problems that result from this public ownership. Regardless of which criteria best justify a public supply of forest-oriented goods and services, the conclusion for investment purposes is the same. Many of the commodities do not command a well-established market demand. No market-established prices can represent the values of recreation and water investment analyses. Despite the established markets for timber and forage in many parts of the country, there has been little study of how closely administered prices of forage approximate market values, nor of how federal timber sale appraisal procedures affect the market price of timber from either federal lands or competing private lands. Thus, the major problem for multiple-use decision makers relative to public lands, is the lack of data that are needed if the benefits from the production of certain commodities or, even more complex, combinations of commodities, are to be evaluated. For some products we have no measures of market value. Whenever demand for goods and services from public resources is totally, or even partially, free to reflect consumers' desires, any mispricing is quite apparent. If overpricing exists, disuse of the resource develops; with underpricing "overuse" may emerge. This process, however, offers a decidedly imperfect substitute for market values.

Nevertheless, some possible approaches to natural resource allocation or investment decisions can be proposed.

Decision Making Techniques

The most common approach to the dilemma of making decisions without value information is to avoid the problem -- that is, use a method that doesn't require value data. Two forms of this approach are:

1) Establish physical production goals at least cost,

2) Maximize physical output for a predetermined level of expenditure.[1]

These two procedures have had hundreds of illustrations in "public forestry" during the past several decades. The forester, for example, may have had a specific budget item for tree planting and within the limits of his budget he tried to plant as many acres as possible. As a result, the

1 See Webster, Henry and Perry Haggenstein, 1963, Economic Analysis of Watershed Management Decisions - What Sort of Guides for Land Managers" Journal of Forestry Vol. 61 No. 9 pp. 631-634.

least promising acres were often planted first, because areas such as the poorly producing mid-western sand flats offer inexpensive planting opportunities. Thus, criteria that do not require value data may result in improper investment priorities from any kind of benefit-cost standpoint.

Investment criteria that make only limited use of product values have had some interesting recent applications. U.S. Forest Service researchers attempted to develop planning models for multiple use management and devised the imaginative Resource Allocation Models. These models have been successfully used with linear programming techniques to determine least-cost solutions for prescribed multiple use goals. The computerized linear program solutions have allowed consideration of extremely complex problems involving many different kinds of costs and physical outputs.

Though these Resource Allocation Models presently offer the best solution to multiproduct output decisions on Forest Service lands, they do not incorporate the important policy issues of what are appropriate production goals. And solutions to these models depend upon first setting the physical production goals. That is, water production, timber cut, or animal unit goals must be determined as inputs into the model. The land manager must determine what is the optimum output from his lands. Thus, even the newest refinements in using cost minimization criteria for solving multiple use decisions do little to guarantee an optimum solution based on measures of public welfare.

Still another way to avoid the value problem, which unfortunately has been used too often, is to claim that no economically rational solution exists. Some would advocate that an uninformed decision in the political arena somehow is superior to other decision making techniques. In truth, however, the best political solution can only be achieved with information regarding benefits and costs.

A second possibility for solving public investment or allocation decisions is what can be called the macro-economic approach. If a major role of public resource utilization is economic development, in its broadest sense, then the techniques of simply minimizing costs or maximizing differences between benefits and cost may not be appropriate to investment decisions on public lands. As Kenneth Boulding states, "The great hiatus in economics . . . is a real link between price theory of any kind and a theory of economic development.[1] If the goal of public resource use is economic development, why not deal with the problem more directly and look at the impacts of certain allocation decisions on such variables as regional or national income, regional or national employment, economic stability, etc.

Though the stated goals of public land management have not explicitly included economic development as a central issue, it is implicit in the justification of certain programs on the basis of stabilizing the livestock industry or protecting a certain locality's lumber industry. Thus, employment and local or regional income considerations do seem to influence public land allocation decisions.

Little or no research has been done concerning the regional or national economic impacts of alternative forest land uses. Only recently has some study been directed toward measuring and predicting the impacts of dams and

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[1] Boulding Kenneth E., 1963. The Uses of Price Theory in Models of Markets. Edited by Alfred R. Oxenfeldt, New York, Columbia University Press, 371 p.

other water developments on surrounding communities. One thing apparent from these few studies is the extreme difficulty of accurately measuring the regional impacts from even multimillion dollar projects.

The size of the region over which impacts are expected has considerable influence on our ability to identify changes due to specific investments. If the relevant region is large, for example a state, one might logically conclude that most measures of macro-economic variables lack sufficient sensitivity to assess changes resulting from the relatively small investments that characterize forest lands or from shifts in land use patterns. If, however, we are interested in measuring impacts on smaller units such as communities, the techniques available, which include input output analysis or economic base analysis, do not seem particularly appropriate for measuring the economic interrelationships that exist within small rural areas. The strong economic dependence of the region under study on distant urban centers tends to cloud the intraregional economic picture.

The macro-economic (or regional analysis) models for making multiple use decisions seem to have three major shortcomings. First, they are not sufficiently sensitive to measure changes associated with small investments.

Second, they do not come to grips with the major policy issue of how much should be invested in the various kinds of development that are possible on public forest lands. At best, we can set criteria that require maximizing the level of employment for a given budget or obtaining a given level of employment at a minimum cost. These use-optimization techniques do not solve the problem of how much money should be invested in various development or use combinations on public lands.

Third, in dealing with aggregate figures for income or employment, we often ignore the problems of income distribution. An apparent increase in regional income may equate with decreased income and employment in other regions. Changes in land use patterns may generate interregional flows of income or they may change the relative contributions of the public and private sectors in supplying resources.

Considering the shortcomings, most economists would agree that the best approach toward ranking alternative land uses would require some attempt to evaluate the difference or ratios between benefits and costs. If evaluation of benefits in relationship to costs is the appropriate criterion, then many analytical models came to the fore. Benefit-cost ratios, internal rates of return, and joint production models equating marginal rates of substitution between goods, are all methods that can be used to compare benefits and costs of various investment schemes.

Though the mechanics of performing these kinds of analysis are relatively simple, they have been little used in analyzing public investment. The attempts by the Corps of Engineers and Bureau of Reclamation to apply these methods could at best be called incomplete unsatisfactory efforts to compare benefits and costs. The dissatisfaction associated with this use stems from the difficulty of assigning a quantitative measure to benefits derived from non-market supplied goods and services. In many instances two of the most important products from water development (and likewise from forest development) are recreation and water for domestic use. Yet neither of these outputs has an established market value which can be plugged into investment analyses. Methods that approach multiple use decisions from a profit maximizing standpoint have therefore been little used because of the lack of value figures for many of the benefits.

This lack has promoted considerable recent research on the problem of resource values. Most of this has dealt with problems of recreation valuation.

Status of Resource Valuation

Before examining the status of resource valuation, it is important to clarify precisely what kind of value we are seeking. Many of the critics of current research in resource valuation are not fully aware of the problems of setting on a particular resource use. Those critics seem to assume that every good or service has an inherent value peculiar to it, and that it is the role of the researcher to find this single unique value for each resource use. This concept of a single inherent value for each commodity is false. Every good and service has several values. Each has a value in exchange. That is, how many goods can be obtained by means of giving up or exchanging one unit of the commodity in question. Each good or service also has a unique value for each individual consumer. This is the amount that the individual's psychic welfare is improved through owning or consuming the particular commodity. A good has a third value that equates with its cost of production.

The fallacy is therefore obvious in an assumption that a particular resource has only one unique value, and that the researcher has but to gaze into a crystal ball to find this heretofore hidden number. Rather, determining a value for a particular recreation experience or for the domestic consumption of water is a problem solved by arriving at an index number (expressed in dollars) that approximates one of the above measures of value. Therefore, the many values of a particular resource may each have a possible application in some resource allocation model. The only valid grounds for criticizing a particular proxy value determined through research are: (1) that it is an index of a value not applicable to a particular allocation model, or (2) that through a flaw in concept or methodology, the index is not an accurate approximation of the value being estimated. Many researchers can and should be criticized, however, for not explicitly stating just what kind of value they are trying to approximate. Without this definition, it is impossible to evaluate the prospective usefulness or accuracy of their estimates.

Most of the research currently directed at valuing non-market supplied resources has been devoted to putting a dollar value on recreation. To date several general kinds of approaches have been applied to the problem. These have included:[1]

Expenditure Method - measures the value of recreation in terms of the total expenditures of recreation.

Gross National Product Method - attempts to measure the contribution of recreation to GNP.

Consumers' Surplus Method - attempts to determine the willingness of individuals to pay for various quantitites of recreation. Instrumental in this method is developing a hypothetical demand curve for recreation.[2]

Cost Method - uses the cost of supplying recreational facilities as a measure of the benefits derived therefrom.

Market Value Method - uses fees charged at private resorts as a proxy value for the value of public-supplied facilities.

Monopoly Revenue Method - uses the estimated revenue that would be obtained by a monopolist owning the recreational site as a measure of benefits.[3]

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[1] For a more complete description of the various methods mentioned see Lerner, Lionel, J., 1962, Quantitative indices of recreational values. Economics in Outdoor Recreational Policy, Report Number II, Western Agricultural Economics Research Council, Committee on the Economics of Water Resources Development.

[2] Wennergren, E. Boyd, 1964. Valuing Non-market Priced Recreational Resources. Land Economics, August 1964.

[3] Brown, William G., Ajmer Singh and Emery Castle, 1964. An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fishery. Oregon Agricultural Experiment Station Technical Bulletin 78, September 1964.

Apparently, there is no dearth of ways to try to evaluate recreation. These methods or modifications of them can be used in valuing other resource uses. Yet there has only been limited success when the calculated values are inserted in resource allocation models. Although we have made in-roads at developing individual resource values, we have yet to develop value systems which allow analysis of complex combinations of resources and resource uses. Even though each of the above valuation schemes has its appropriate use in isolated circumstances, their application in resource allocation models must be evaluated on the bases of:

1. their appropriateness for measuring benefits in terms of the optimization criteria of the allocation model.
2. the comparability of all measures of value in the allocation model. It is impossible to approach an optimum solution if cattle, timber, recreation, and water are all measured by different indices of value.
3. whether the value scheme is empirically quantifiable.

Where to From Here?

An orderly approach to multiple use decision-making requires a reorientation of research toward a broader approach to the development of resource allocation and investment models.

The initial stage of this project was thus concerned with developing values of goods from forest lands which would be comparable theoretically and also useful in allocation models. This problem seems to be divisible into two rather distinct parts: (1) the role that "demand" plays in the value process, and (2) the role that "supply" plays in the value process.

To our knowledge, this is the first research which has attempted to come to grips with both of these aspects of the role that valuation plays in decision making. Previous research in valuing recreation, for example, usually concentrated on the demand side of the valuation equation without explicit consideration of the supply side of the equation. Similarly most of the research developing allocation models do not explicitly deal with the valuation problem.

We hope that the following is a conceptual contribution, and we will conclude with a description of research needs to test the models developed.

DEMAND ANALYSIS FOR GOODS AND SERVICES PRODUCED ON FOREST LANDS

Traditional demand theory characterizes the quantity of a good or service demanded by consumers as a function of price. Further, the law of demand states that the amount of a good or service demanded increases with a fall in price and diminishes with a rise in price. Thus, the inverse relationship between price and quantity demanded can be described as ahown in Figure 1 where DD represents the traditional demand curve.

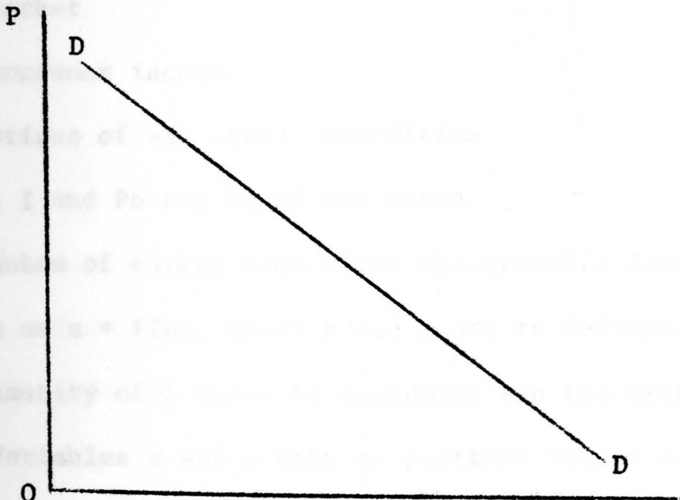

Figure 1. A hypothetical market demand curve (DD)

The negative slope of DD is due to the diminishing marginal utility of the good or service in question. Utility per unit decreases as an individual acquires more of a commodity. In the abstract demand is a static concept. Although only one point is observable at any given point in time, economists act as though the whole curve were known.

In this simplified expression of demand the quantity of Good X consumed is uniquely dependent on the price of X ruling in the market. In order to obtain such a simple representation of quantity of Good X demanded in a market consisting of a given group of consumers, the following assumptions must be made:

$Q = f(P, \underline{C}, \underline{T}, \underline{I}, \underline{Po})$

Where P = price of the commodity X

C = number of consumers

T = tastes and preferences of consumers for all goods sold in the market

I = consumer income

Po = prices of all other commodities

C, T, I and Po are fixed and known

From this expression of market conditions the symbolic demand function for X can be written as $x = f(p)$, where x and p are in definite units and represent the quantity of X taken by consumers and the market price of X respectively. Variables x and p take on positive values only.

It is desirable at this point to go behind the market demand curve and see how it is developed. The market demand curve is made up of individual demand curves. At any given price the total quantity of X taken in the market is nothing more than the horizontal summation of the quantities demanded by individual consumers. If we want to know more about the market demand curve we must investigate the individual demand curves.

The goods and services that an individual can purchase are limited by his income and wealth and by prices at which goods and services are made available. Subject to these limitations the individual chooses which goods and services to purchase. In doing so, the individual makes decisions which maximize his "utility", where "utility" is a common characteristic of all goods and services. For example, consider n consumer goods (X_1, X_2, X_3---, Xn). Let one form of the utility function of the individual be U = (X_1, X_2, X_3,---, Xn). The individual having a given income, I , can purchase goods at uniform market prices (P_1, P_2, P_3,---,Pn). Purchases are made so that U has a maximum value subject to the conditions expressing the fact that he must balance his budget:

$$X_1P_1 + X_2P_2 + X_3P_3 + \text{---} + XnPn = I$$

If the individual consumer is to maximize his utility function subject to the above restraint, it can be shown mathematically (1) by using Lagrangian multipliers that the following result must be obtained:

$$\frac{UX_1}{Px_1} = \frac{UX_2}{Px_2} = \frac{UX_3}{Px_3} = \text{---} + \frac{UXn}{Pn}$$

Then the individual has allocated his income among goods, X_1. X_2, X_3, --- Xn, so that marginal utility per unit of income is equal among all goods and services consumed.

The market demand curve in its simplified form represents the sum of all individual demand curves in the market, which in turn represent consumer choices relative to prices for some given time period. And, as Marshall stated:

> "- - - But in the long run the price which a trader or manufacturer can afford to pay for a thing depends on the prices which consumers pay for it, or for the things made by and of it. The ultimate regulator of all demand is therefore consumers' demand."[1]

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1 Marshal, Alfred. 1947. Principle of Economics. MacMillan and Co. London. page 92.

The Competitive Market

In a purely competitive market, supply and demand conditions determine market prices for all goods and services entering the market. In any specific market area the consumer can buy a given product from a number of firms. If all firms are equally convenient and sell products of comparable quality and if buyers incur similar amounts of non-market costs, etc., then price is the criterion used by the consumer to make decisions concerning income allocation. When prices are equal and the "ceteris paribus" assumptions hold, then the consumer is indifferent as to where purchases are made. However, if any of the above assumptions are relaxed, then price becomes only one of the determinants of demand, and the quantity of Good X demanded by the consumer from a particular firm or all firms is now a function of price and the other variable(s) allowed to change. No one will travel outside a market area for the sole purpose of buying a product he could have purchased in a closer market for the same price. To do so would be irrational because of additional travel costs. Prices between market areas normally differ by the cost of transportation and added handling costs from point of production

Let us consider traditional community markets where the consumer is in several overlapping market areas (Figure 2). First, consider the case where acquisition costs for Consumer C are approximately equal at Stores M_1, ,$_2$, or M_3, because C is an equal distance from all three markets.

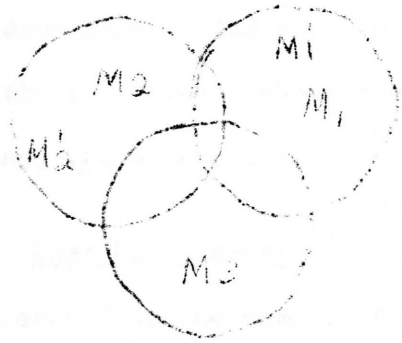

Figure 2. Three assumed markets in a traditional market situation

Price differentials properly determine the place of purchase. Where price in $M_1 > M_2 < M_3$, the consumer would shop at Market M_2. Now let us consider another case where Consumer C is located at varying distances from three sources, M_1', M_2' and M_3', and sale prices are equal. In this case acquisition costs determine the place of purchase and C would shop at M_3. The traditional demand function $q = f(P)$ can be restated for this situation as $q = f(P, Ac)$ where Ac is acquisition costs in addition to price.

It is evident that where consumers are located at various distances from the market there are costs incurred in addition to price which influence an individual's willingness to consume. Price is but one variable which affects his income allocation. A more applicable variable to analyze consumer demand for this type of market situation is user cost (UC).

A consumer of goods and services produced on a national forest is exactly analogous to the second case described in Figure 2. For goods and services produced on national forests, acquisition costs become more dominant in decision-making as distance to the product source increases. The cost of using (consuming) national forest products is not just the price at the site, which for some products is zero, but involves all costs to consume. Thus, the common denominator used in this paper is user cost and is measured at the gate of the first user--the lumber mill, the rancher, the hunter, the canal company, the hiker, etc.

User Cost Theory

The idea of user costs stem from the theory of equi-marginal value in use principle which asserts that economic goods and services have measurable value. The word "value" has often been used to express different viewpoints. Adam Smith said:

> "The word value, it is observed, has two different meanings, and sometimes expresses the utility of some particular object, and sometimes the power of purchasing other goods which the possession of that object conveys. The one may be called 'value in use'; the other, 'value in exchange'."[1]

Through almost universal acceptance of the value in use principle, a product or service has value which is measured as the maximum amount of dollars which a user will be willing to pay for that unit. Marginal value in use is the value of the last unit consumed. The principle of marginal value in use further asserts that an efficient allocation of resources exists between users and uses when the values in use of the marginal units are equal for each user and use. If marginal value in use of a resource is not equal between uses or between users, then resources must be free to move from one use to another or from one user

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1 Smith Adam, 1776. Wealth of Nations. Gateway Edition, Herney Regnary Co. Chicago Illinois, 1953.

to another until no advantage is to be had from trading before resources are correctly allocated.

Acceptance of the value in use principle is a stepping stone which permits further development of the concept referred to in this paper as user cost. Since consumers allocate their fixed income among goods and services in such a way that total utility derived is at a maximum, it appears feasible to measure value in use as total outlay of dollars needed to consume goods and services. In this light what an individual pays to consume non-market-priced goods as well as market-priced goods is evidence of value in use. Equating marginal value in use and user cost is diagrammed in Figure 3. The individual consumer will attempt to

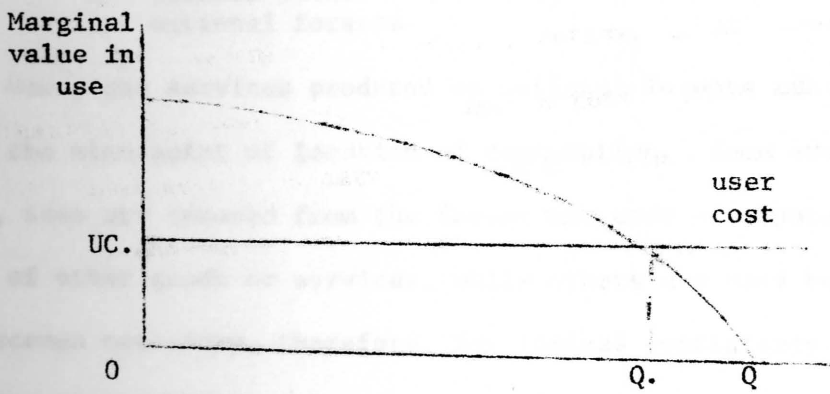


Figure 3. Marginal value in use and user cost relationship

consume Qo of the product at User Cost UC. Only restraints such as lack of capital or limited supply of Q will prohibit him from doing so. User cost includes all costs which would not have been incurred had the good or service not been consumed. These expenditures by the consumer are measures of satisfaction or personal benefits derived from consumption and are evident from his willingness to pay. The sum of all user costs are total economic benefits since it includes the expenses paid by all consumers to all other individuals providing goods and services to the consumer.

Society obviously benefits from expenditures made for the use of national forest resources and if maximization of economic benefits is the goal, then goods and services should be allocated to users so the following function is maximized:

$$EB = \sum_{i=1}^{n} UC_i$$

where

EB = economic benefits

UC = user cost

i = various products (1, 2, 3, --- n) produced on the national forests

Goods and services produced on national forests are heterogenous from the standpoint of location of consumption. Some are consumed on the site, some are removed from the forest and used as inputs in the production of other goods or services, while others are used but never consumed. It becomes necessary, therefore, for logical consistency in the valuation process to establish a starting point for user cost measurement. This point we call the "gate of the first user" and it represents the point at which costs are first incurred in the consumption of national forest products. The user gate for the recreationalist is his home, for the grazer of domestic livestock it is his ranch; for the logger it is his mill, etc. The user cost for the sawmill could be computed as follows:

$$UC_T = \Sigma C_1 + C_2 + C_3 + \text{---} + Cn$$

where

UC_T = total user cost per 1000 board feet in logs at the mill

C_1 = bid price

C_2 = transportation

C_3 = on site labor

C_n = other acquisition costs

Total UC to harvest timber from a given forest could be represented by

$$TUC_T = \sum_{j=1}^{m} \sum_{i=1}^{n} Cij$$

where

TUC_T = total user cost for all logs at mills

Ci = cost of the ith expenditure

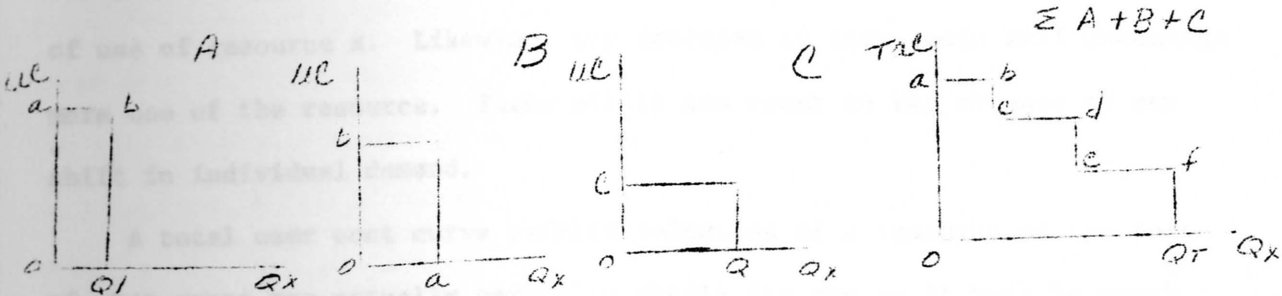
i = different variable user costs (1 to n)

j = number of users (1 to m)

There is a subtle difference between user cost and traditional demand theory. Whereas only one point on a demand curve exists at a given point in time, points on the user cost curve exist at a given time period because of consumer and product location differences if nothing else.

Derivation of a Total User Cost Curve

Assuming the relationship qx = f(UC), where UC is all the variable costs involved in the consumption process of resource x, a graphical presentation of a total user cost curve (TUC) can be drawn. TUC represents a summation of individualsusers costs and is more fully described in the following example where individual users A, B, and C expend costs UC to consume quantities Q of resource x. The area inclosed by $OABQ_1$ represents the user cost for user A to consume an amount Q_1 of resource x. The sum of users cost for users A, B and C is the total user cost expended to consume Q_T unit of x during a given time period and is the area enclosed by $OabcdefQ_r$.



In Figure 4 a graphical presentation of a total user cost curve is shown. The least cost,

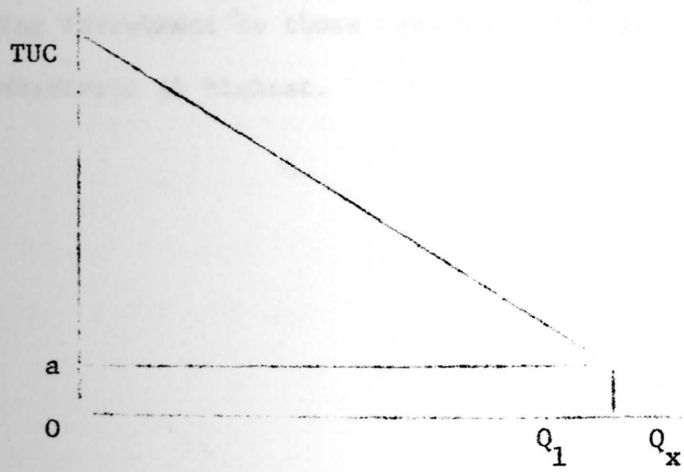


Figure 4 Hypothetical total user cost curve for a given resource

Oa, is incurred by those users nearest the site, part of which could be a fee charge. Thus, the total user cost curve will not indicate on output higher than Q_1 unless the MU per dollar of expenditure increases for some or all users. The assumption here is that users equate marginal user costs to marginal utility derived from use of the resource. Thus, any fee change or any other alteration in user costs associated with a given level of resource use will shift the derived curve. An increase in fees, for example, will cause some users to leave the market and reduce the quantity of use of resource x. Likewise, any decrease in user costs will encourage more use of the resource. These shifts can occur in the absence of any shift in individual demand.

A total user cost curve permits valuation of a resource on the basis of what users are actually paying to obtain its use -- it must be worth at least that much. On National Forests where multiple products are produced, TUC curves can be derived for each use. Some of these resources are associated with prescribed use levels (sustained yield, etc.). User cost curves can be useful aids to incremental investment decisions by guiding investment to those uses where public expenditures per dollar of investment is highest.

Summary

The user cost approach has many of the pitfalls that other approaches have when used for resource evaluation and allocation purposes. However, it does provide a framework for analysis of resource allocation in a multiple use setting. User cost is not so different from the usual price found in traditional markets and it plays the same role in the allocation model that price normally plays. It does have an advantage in the present contest in that it can be determined empirically for every product or service harvested from the national forests. The gate of the first user provides a consistent point to measure user costs. At that gate all the pressures in the economy culminate in the consumer's decision as to when, how much, and where he will consume all goods and services available to him. The basic premise underlying user cost is that resources should be evaluated on the basis of their value in use. Thus, the theory of the consumer in equating marginal utility per dollar spent in all directions is basic to the user cost model as it is in traditional demand analysis.

SUPPLY ANALYSIS FOR GOODS AND SERVICES PRODUCED ON FOREST LANDS

The process of making goods and services from public resources available to the consuming public is no longer a costless one. In some cases the costs of supplying these goods may be quite small, consisting of administration costs and minimal other expenses. The maintenance of a hiking trail in a wilderness may be such a service. Yet, as public natural resources become more scarce or the demand on them increases, the costs of supplying these goods and services are certain to increase. As costs of supplying resources increase they must play a critical role in allocation and investment decisions.

In the introductory section, the point was made that the traditional market price is simply an "equilibrating point which at once represents the 'value' to the consumer of the marginal good purchased and the 'value' to the producer of the marginal good produced." The importance of both supply and demand conditions in the generation of values from a resource system was emphasized. The Supply equal Demand condition implies a myriad of things to economists. Comprehension of some of those requires a firm understanding of the theory of supply.

In what follows the theory of supply is reviewed; the supply situation on public lands as we see it is described; and finally a theoretical supply model that seems appropriate to a pseudo-closed resource,[1] such as Beaver Creek Watershed, is suggested.

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[1] The term "pseudo-closed resource system" refers to a management unit such as a forest or watershed such as Beaver Creek. The assumption, which is somewhat unrealistic, is that this management unit serves a market in its entirity. This allows us to apply market type analysis to the system.

Supply Theory

A simple definition of a supply function is a positively sloping curve relating quantities offered to price. This definition leaves one with very little useful information. An alternative definition is available if the problem is approached from the producer's side of the questions.

Conventional price theory tells us that a producing firm will supply its output in accord with that part of its marginal cost schedule (MC) which lies above its average variable cost curve (AVC)[1] where $MC = \Delta TC/\Delta X$. This condition is illustrated by figure I.

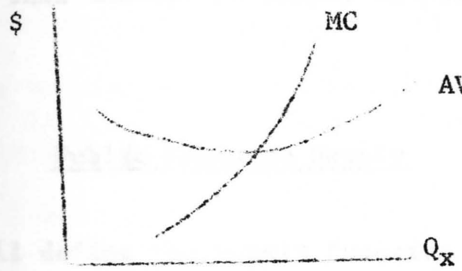

Figure I.

This definition still leaves one with little information and a sterile concept of supply. What is needed is a clear definition of marginal cost.

Consider a production function with one output (Q) and two inputs (A&B)

(1) $$Q = f\ (A,B)$$

---

[1] It is important to recall that the definition of variable costs depends upon the long-run short-run consideration. In this instance, I suggest that it is a long-run we are dealing with.

The respective marginal products of A and B are defined as:

(2) $$MPP_A = \partial Q/\partial A$$

$$MPP_B = \partial Q/\ \partial B$$

From conventional price theory, we can then define the marginal cost of production in equalibrium as:

(3) $$MC = P_{A/}\ MPP_A = P_{B/}MPP_B$$

or $$MC = P_A/\partial Q/\partial_A = P_B/\partial Q/\partial B$$

By proceeding with the above demonstration, we have clearly focused our attention on the fact that the marginal costs and thus the supply function of a firm are derived directly from the production function faced by the firm. How does this concept of supply compare to situations in resource management?

Public Resource Supply

Ultimately, we will define the supply function of a closed resource system such as Beaver Creek in a very rigorous manner, but first we should examine the concepts of supply now commonly held by various groups. These concepts are illustrated in Figure II below.

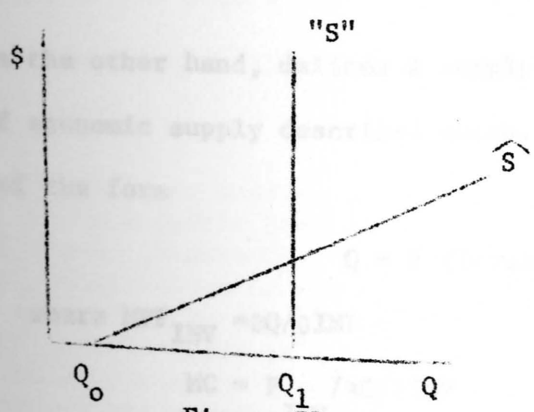

Figure II

"S" is the concept of supply most commonly held by resource managers. This function describes the allowable cut or range allotment situation. "S" is clearly not related to the concept of economic supply discussed above, but has economic implications. "S" is administratively set so as to agree with the administrator's pre-set objectives. Its position has little to do with market or economic phenomenon.

"S" can more realistically be considered a quota usually determined by means of biological criteria. Allowable cut is generally an annual cutting recommendation based on an attempt to harvest growth plus a correction for adjusting the timber stand in the direction of a "regulated condition." Likewise grazing allotments are usually determined by some estimate of a sustainable amount of forage production. Generally, allowable cut or allowable grazing are quotas or biological limits which can be met with a minimum of direct investment of funds.

These consumption limits or quotas are not affected by the cost of producing the resource and thus appear as a vertical line. That is, output doesn't vary with the costs of production or the price of the commodity in the market.

Supply a Function of Investment

$\hat{S}$, on the other hand, defines a supply function quite similar to the concept of economic supply described above. We are assuming a production function of the form

(4) $$Q = f\ (\text{Investment})$$

where $MPP_{INV} = \partial Q/\partial INV$

(5) $$MC = P_{INV} / \partial Q/\partial INV$$

Critical examination of S reveals that it too is unacceptable as an explanation of economic supply. S clearly begs the confounding problem of opportunity costs so prevalent in public resource allocation questions.[1]

Since opportunity costs are important in resource allocation decisions, some consideration of them is vital.

Supply and Opportunity Costs

Where uses of a public resource compete, production of one implies non-production, at least to some degree, of others. That is, there are opportunity costs associated with every investment decision. The production function is not merely

$$Q_1 = f\ (\text{Investment}).$$

It is more like

(6) $$Q_1 = f\ (\text{Investment},\ Q_2,\ Q_3,\ \ldots\ Q_n).$$

This in turn yields a marginal cost function which is quite different from

(7) $$MC = P_I / \partial Q / \partial\, INV$$

as defined above.

Clearly, we now have a total cost function of the form:

(8) TC = (Investment Costs) + (Opportunity)

---

1 It is informative to discuss the point Q_o in Figure II. Q_o is the level of sustainable production the untreated biotic system is capable of with zero investment. The location of this obviously depends upon the physical nature of the system considered. It is interesting to note that "S" (the present administered supply) could be set either to the left or right of Q_o. Assigning "S" a position on either side of Q_o opens the door to a number of questions, but since they are not directly relevant to what follows they will not be considered.

This in turn yields us a marginal cost function for Q_1 of the form:

(9) $$MC = \partial TC/\partial Q_1 = \partial INV/\partial_{Q1} + \partial OPP/\partial_{Q1}$$

A Revised Supply Function

For simplicity, assume a two-good system in which production is defined by a curvilinear production function embodying the assumption of diminishing returns.[1]

The for good one (Q_1),

$$MC_1 = \partial TC/\partial Q_1 = \partial + \beta Q_1 = P_1 \Delta Q_2$$

where $\partial INV/\partial Q_1 = \partial + \beta Q_1$

$\partial\ OPPC/\partial Q_1 = -P_2 \Delta Q_2$[2]

P_2 = price of Q_2

This then yields a supply function for Q_1 similar to that of Figure III.

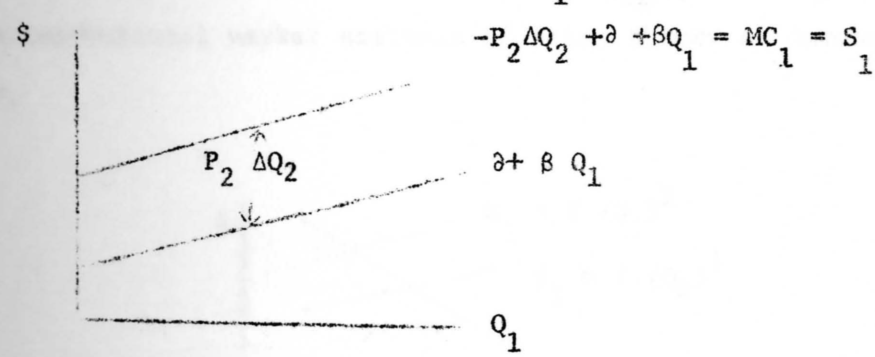

Figure III

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[1] Note that the curvilinear production function and the assumption of diminishing returns are not essential to the discussion that follows. A market equilibrium normally would still be attained without these assumptions.

[2] The term $- P\Delta Q_2$ will satisfy the alternative good relationships (i.e. complimentary, competitive, non-related).

Implicit in this argument is the fact that for every level of Q_2 production, there corresponds a different supply function for Q_1. This is illustrated by Figure IV.

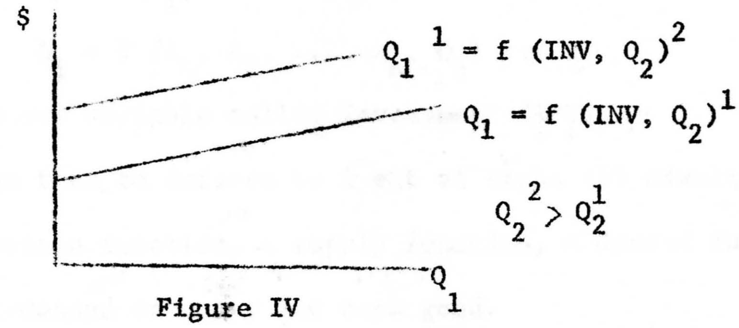

Figure IV

Equilibrium Value

If we add a demand function for Q_1 to the system, a pseudo-market equilibrium price is generated for each possible production level of Q_2. This is the conventional market analysis of price theory as demonstrated in Figure V.

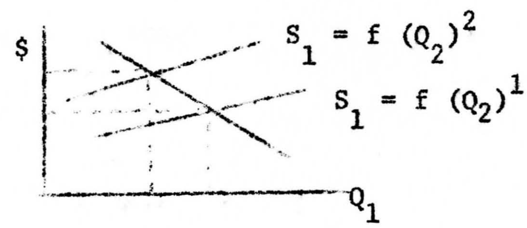

Figure V

Since this is the variable (equilibrium price) of concern, it would seem that we have a possible scheme for analysis.

The Model

From the above discussion it is obvious that a complete system would consist of a production function, a supply function, and a demand function for each good. This in essence is the basis for the supply model.

For simplicity we again assume a two-good system. We further will assume that all the inputs (A_i) of the production function

$$Q_i = f\ (A_L, A_2, \ldots, A_n, Q_k)\ k \neq i$$

can be grouped into one variable called Investment (INV).

This system can then be defined by a set of eight (8) simultaneous equations: a production function, a supply function, a demand function, plus a supply-equal-demand identity for each good.

Symbolically these equations are:

(11) $Q_1^p = f\ (INV_1, Q_2^p)$

(12) $Q_2^p = f\ (INV_2, Q_1^p)$

(13) $Q_1^d = f\ (P_1)$

(14) $Q_2^d = f\ (P_2)$

(15) $Q_1^s = f\ (P_L, Q_2^p)$

(16) $Q_2^s = f\ (P_2, Q_1^p)$

(17) $Q_1^s = Q_1^d$

(18) $Q_2^s = Q_2^d$

where

Q_i^p = quantity of i the good produced

Q_i^s = " " " " " supplied

Q_i^d = " " " " " demanded

pi = price of the i th good

INV_i = variable investment costs of production associated with the i th good.

The system is characterized by eight (8) endogenous variables:

Q_1^p $\qquad$ Q_1^d

Q_2^p $\qquad$ Q_2^d

Q_1^s $\qquad$ P_1

Q_2^s $\qquad$ P_2

Which is consistent with the eight equations defined.

Conclusions

This system would generate the equilibrium values of the several products. The main thrust of the system is an attempt to approximate a market supply function which is vital to the allocation model we are hypothesizing.

The supply function generated by the system will be more complete than past attempts in that it not only considers the variable costs of production but also the opportunity costs so prevalent in public resource management decisions.

The model presented seems to be theoretically sound. It will generate an efficient allocation of resources at the firm and in the case hypothesized, at the market level. Of course, there is the ever present question concerning violation of the perfect competition assumption. Obviously the worth of the model will depend to some degree on the extent of violence done to this often attacked assumption. Depending upon one's requirements for the definition of a competitive market, the assumption will not or will be acceptable. If one insists on the text book list of criteria (many firms, many buyers, etc.) the assumption will rarely be accepted. If, on the other hand, one is interested in the effective results of the market process (MC of production = marginal value in use), the assumption will be acceptable in many cases. Further discussion of this point is not warranted in this paper, since justification or negation of this approach to analysis of market structure rapidly degenerates into parroting of one's educated biases.

Even if one grants the empirical validity of the proposed model, the empirical infeasibility of the system should be a sufficient block buster to satify critics.

The production function is obviously the central building block of the system, and the absence of multiple input-output models from the empirical horizon is evidence of the problem. Adequate data for such an involved estimation procedure is just not available. Consider the multiple input two output model suggested. The system defined eight endogenous variables. Couple this with a minimum of twenty or thirty exogenous variables and the problem becomes obvious. To obtain any significant silmultaneous estimation of the system's parameters would reguire fifty to one hundred observations in all probability. Anyone acquainted with the data available for natural resource systems will recognize the almost insurmountable task of acquiring a number of observations even approaching this.

The question of existence of stable production functions may also be raised. Some imply that even if all the data needed were available, the functions could not be estimated. This seems to be an unfounded conclusion. In a world where cause and effect are accepted by most, the complexity of the functions, not their existence, would seem to be the problem or point of debate.

This implies that with a fully specified model and adequate data, the function could be estimated. In the case of some human behavior, the functions may be so complex as to render them practically useless. Production functions on the other hand do not seem to warrant the same conclusion. The problem, therefore, would seem to be data alone.

At any rate, in the context of the proposed model, the apparent inavailability of appropriate production functions forces us to retreat to the traditional concept of natural resource supply (i.e. administratively set supply "S" of Figure II).

What does this imply for the proposed model? It implies questions of significant proportion. The basis of support for the proposed model was implicitely traditional efficiency criteria. That is, marginal costs in production should equal marginal value in use. Since "S" involves no consideration of the costs of production directly, the efficiency conditions will not be defined by the model unless it is by chance. This leaves us on very unsure footing. The only conclusion possible is that the supply curve will intersect the user cost curve some where. The meaning of this point is unclear from a welfare point of view. It does, however, define a price or value index of some sort. The possibility exists that a "politically" or "administratively" determined inelastic supply curve in addition to considering marginal costs of production also considers social opportunity costs and thus is a closer approximation of a "public supply curve".

NEEDED RESEARCH

The model proposed incroporates concepts not currently used in forest service decision making. Thus, data are available only in bits and pieces. Yet, there may well be more data available than commonly thought.

Data Needs-Supply

Ideally, estimates of single use production functions for any site being studies are needed. Also derived estimates of input substitution relations among all uses as well as product substitution relations among all uses are necessary. With these physical functions, the associated benefits and costs, and a computer program, testing the model is possible. Obviously, the ideal is far from a reality and will be for some time. Still, most decisions in life are based upon something less than perfect information. The use of a rational technique and limited data produces rational decisions. Even though the error may be large, it will normally be smaller than it would be if based on an irrational technique.

Generally, physical relationships such as production or substitution functions are curvilinear in the range where economics enters the decision-making process. Linear relations are the exception rather than the rule, and it is doubtful if there are many linear cases among the uses made of public forest lands. Of course, it would be desirable to have data over the whole range of each function. Though these data are not currently available, if we can find points and specify an appropriate mathematical function, some of these economic relationships can be estimated. The Forest Service and State Experiment Stations have some points established from which a supply function can be synthesized for several uses and several sites. Physical data will be relatively more difficult to generate than the cost data related to supply extending or shifting.

Data Needs-Demand

The demand function (UC) for each use for a given site will have to be estimated from data obtained from the society of users. Samples, survey questionnaires, and on-site checks as well as secondary sources will need to be employed. Since we are concerned with a synthesized test of the model at this time, a relatively small user area would be selected in order to minimize the costs of obtaining data.

Estimates of a UC function for each use for a given area can be made with considerably more confidence than can estimates of supply costs because more points along the significant range in the functions can be determined. Also, there is already considerable experience in estimating these functions for some uses.

Identifying the Restrictions

The allocation decision depends not only upon UC and supply costs, but also upon physical and institutional limitations. A major limitation is the allowable harvest limit on the supply side. For most traditional uses administrative decisions, budget restrictions, experience, and research have established it.

Making the System Operational

Finding the data needed is only part of the testing problem. Selecting the analytical system that will best accommodate the data, provide the maximizing allocation solution, and be practical for field use is equally difficult. Obviously, computers will have to be employed to handle the many inputs required by the allocation problem. Alternative systems need to be tried in the testing stage and the results of each need to be studied in relation to the logic of the model.

Application to field problems will vary in complexity; some sites will have all use possibilities; some will serve people from all over the country; and some will accommodate many techniques for producing the product or service. Such a complex problem may require a national study program using a large computer. A site with only one or two uses, serving a local community, and having only one or two ways of doing the job might be studied by a qualified man with a program and a calculator. Data for intermediate problems could be sent to a regional computer center for analysis.

Programs for computers and selection of the analytical techniques to satisfy the requirements of the model need to be specified and tested during the research program. We argue that such activities are part of the research process and in the end will save time and money and help standardize the decision-making processes.

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