ESTIMATING THE ECONOMIC VALUE OF NATURAL COASTAL WETLANDS: A CAUTIONARY NOTE

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Research Report
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ALTERNATIVE MANAGEMENT STRATEGIES
FOR
VIRGINIA'S COASTAL WETLANDS
SEA GRANT PROJECT PAPER
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FOREWARD

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1. Alternative Management Strategies for Virginia's Coastal Wetlands: A Program of Study	
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Additional publications concerning development and preservation values of coastal wetlands as well as alternative wetlands management strategies will be forthcoming.

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Estimating the Economic Value of
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ABSTRACT

Public involvement with the management and use of wetlands resources has stimulated interest in obtaining monetary evaluation of the nonmarket ecological services of wetlands in order to better weigh the benefits and costs of altering wetlands. The most prominent study to date that evaluates wetlands is Gosselink, Odum and Pope's (GOP) The Value of the Tidal Marsh. There are, however, serious problems with that study that have not been recognized by the current users of those estimates. This report is a critique of the methodology used in The Value of the Tidal Marsh; it identifies the major conceptual errors in the methodology and demonstrates that there is reason to be skeptical of the estimates of the economic value of marshland.

INTRODUCTION

Marine wetlands, in their natural state, yield numerous valuable services such as provision of nursery and feeding habitat for fish and wildlife and assimilating waste. On the other hand, these same tracts of land, when filled or otherwise altered, can provide housing, commercial and recreational services. In the past, the decision to modify natural wetlands in order to capture the services of development has been made by private individuals who are subject primarily to forces in the land market. Alteration of wetlands, at the appropriate time and place, meant that the owner was then able to sell the land at a price which reflected the social benefits of the development services he provided. However, private owners of natural wetlands find no ready market for sale of the services of fishery habitat or other such "natural" services. Problems of ill defined property rights, high cost of exclusion and transaction, and technological interdependencies make the existence of markets that can make natural wetland services vendable nearly impossible. Therefore, private owners of wetlands are unlikely to receive market price signals that will encourage them to maintain their wetlands in a natural state. Rather, conversion of wetlands to development services is encouraged whenever market conditions dictate such a move. This conversion is made with little recognition of the opportunity cost of natural services foregone.

In recent years, public dissatisfaction has been directed at the pattern of wetland use that has resulted from unregulated private market transactions. A recognition of the potential social value of natural wetlands has emerged through the political process and resulted in legislation to modify the wetlands market by placing restrictions on wetland conversions. A good example of this changing recognition can be found in changes in the code of the Commonwealth of Virginia. A 1910 policy stated:

> It is hereby declared that the drainage of the surface water from wet agricultural lands is essential for the successful cultivation of such land and the prosperity of the community, and the reclamation of overflowed swamps and tidal marshes shall be considered a public benefit and conducive to the public health, convenience, utility and welfare [27, sec. 21-293 (1975)].

However, by 1972, on the basis of the same public welfare rationale, the following policy statement in the Virginia Wetlands Act was adopted by the Virginia legislature:

> Therefore, in order to protect the public interest, promote the public health, safety and the economic and general welfare of the Commonwealth, and to protect public and private property, wildlife, marine fisheries and the natural environment, it is declared to be the public policy of this Commonwealth to preserve the wetlands and to accomodate necessary economic development in a manner consistent with wetlands preservation [27, 62.1-13.1 (1973)].

The Wetlands Act requires that before alterations of wetlands can be made, the board then grants a permit if it finds "...that the anticipated public and private benefit of the proposed activity exceeds the anticipated public and private detriment and that the proposed activity would not violate or tend to violate the purposes and intent of [the wetlands legislation]. ..[27, sec. 62.1-13.5 (9)(b)(1973)]. Thus, the Act requires that a conscious balancing of natural and development values be made before wetlands are modified.

Also, Federal legislation now requires consideration of natural values as well as development values. For example, Section 404 of the Federal Water Pollution Control Act amendments of 1972 (FWPCA), gave the Army Corps of Engineers jurisdiction over coastal wetlands [4]. Present Corps policy for evaluating permit applications with regard to their impact on wetlands will not be granted unless an analysis indicates "...that the benefits of the proposed alteration outweigh the damage to the wetlands resource and the proposed alteration is necessary to realize those benefits" [4, p. 37137].

This need to weigh the benefits and costs of altering wetlands, in turn, has stimulated interest in obtaining monetary evaluations on nonmarket ecological services of wetlands [23, 2]. If this could be accomplished, the opportunity costs of wetlands development (or the benefits of wetland preservation) could be more clearly identified and compared with the benefits of wetland development. Of course, a major constraint on such measurement efforts is the non-existence of markets for services of natural wetlands. Failure of these markets to exist means that price information upon which to base value estimates is absent. Therefore, some form of shadow pricing for natural wetlands services is needed in order to provide economic value information which can aid in determining the allocation of wetlands between natural and development uses.[1/]

Initially, this void in estimated values of natural and coastal wetlands has been filled by one study. Gosselink, Odum and Pope (hereafter referred to as GOP), approached the monetary evaluation of natural wetlands in four ways. First, using what they termed a "life support" valuation, they estimated the value of unaltered wetlands as high as $82,000 per acre [6]. GOP obtained lesser estimates of wetland values based on estimates of the value of the contribution of wetlland to fisheries production ($2,000/acre), the value of the potential of wetland acreage for oyster aquaculture development ($31,500/acre), and the value of marshlands for waste assimilation services ($50,000/acre).

Perhaps the most significant result of the GOP study is the extent to which it has since been used by analysts and cited in policy discussions. For instance, GOP's research was entered, in several different places, into the hearings record on Section 404 of the Federal Water Pollution Control Act amendments of 1972 [26]. The record included two papers by Odum which cited GOP's evaluations, use of the GOP estimates to place monetary values on marshlands on Cape Cod and in the Delaware River, and citation of the GOP estimates in a letter from "Rivers Unlimited." In addition to these hearings, GOP's estimates can be found in the 1974 U.S. Council on

Environmental Quality report:

> "A study last year proposed an additional, al economic/ environmental perspective on the value of coastal wetlands, estimating that natural functions of tidal marshes--in cleaning air and water, providing nursery beds for marine fisheries, buffering hurricanes, and in providing scenic and recreational values--is worth $85,000/acre/year compared to $1,000-$3,000 per acre if filled for urban use" [3, pp. 203-204].

Also, Pope and Gosselink used GOP estimates in an article reported in the Coastal Zone Management Journal where they outline a "rationale and technique for putting a cash value on the ecological values of a tidal marsh" [23, p. 65].

Indeed, one of the principal authors of the study has claimed that the GOP estimates have had a persuasive impact on policy making.

> "Because we could document the work and, therefore, the value of these estuaries, our findings have been widely used as a basis for formulating law and other measures to protect the U.S. coastal zone from insidious alterations" [17].

While GOP's attempt to assess the economic value of wetland is laudable, and clearly tries to provide information that is currently in demand, some serious questions need to be raised about their estimates of marsh values. Others have rejected the GOP methodology and findings as showing "only the most casual understanding of the techniques developed by economists for market analysis..." [28, p. 203]. However, the serious problems with the GOP estimates have not been fully documented and clearly have not been recognized by the current users of those estimates. It is important that analysts and policy-makers involved in coastal resource management be aware of these conceptual problems. Therefore, the subsequent discussion will identify the major conceptual errors in the GOP methodology and will demonstrate that there is reason to be skeptical of the GOP estimates of the economic value of marshlands. The focus will be first upon their "life support" values and then upon their valuation of direct wetland services.

LIFE SUPPORT VALUES

The Ecosystem Approach to Valuation of Natural Environments

Using a methodology developed by Howard Odum [19, 20], GOP calculated the life support value of an acre of marshland at nearly $82,000. The calculation is based upon:

> "an 'ecosystem' approach for translating the total work of nature into monetary terms, so that the overall value of a delimited natural area can be determined without having to specify how the work flow might be divided into different uses and function" [6, p. 17].

The monetary value of the work of nature is calculated by multiplying calories of energy resulting from primary production of an acre of representative marsh by a dollar value per calorie. This dollar value was obtained by dividing Gross National Product (GNP) by the National Energy Consumption Index to calculate an average amount of energy consumed per dollar of output in the United States. This methodology carefully follows Odum's ecosystem approach for calculating life support value of natural systems; it is this ecosystem approach, therefore, that needs to be critically examined.

The fundamental premise of the ecosystem methodology is that society's use of resources should maximize the net energy production of the total environment and thereby find the optimal proportion between "natural" and "developed" environments [18]. As such, man maximizes the total work of his enviroment, and by extension will maximize the value of that environment. The argument concludes that "it is not human beings and their money that determine what is important; it is all the world's energy [20, p. 50].[2/]

With an objective function of maximum net energy, the common unit of energy measure used is the calorie. Thus, because the maximization of net energy output is the criterion for determining optimal resource use, net calorie output of alternative resource use patterns must be measured. While this analytical framework is the recommended ideal, its proponents argue that "a stronger economic basis for justifying the preservation of natural environments is obtained if we calculate the work of nature in terms of dollars [rather than calories]..." [18, p. 184]. This calculation is accomplised by establishing a linkage between the dollar numeraire of the economic system and the calorie numeraire of ecological systems based upon calculation of "an average ratio of money flow to energy" [20, p. 52]. As noted above, the link between dollars and energy use is obtained by dividing Gross National Product (GNP) by the National Power Consumption Index. The justification for establishing this linkage stems from the proponents belief that all systems, the economic system included, are driven by energy flows. They argue that, "money can go around only if energy flows through the system to support the work that money buys" [20, p. 52], and that "ultimately prices are determined by energy" [20, p. 5]. With this argument, the proponents of this valuation system are able to calculate monetary values of particular environmental resources by multiplying net energy output of a particular resource times the calculated ratio of GNP to energy consumption.[3/]

Thus, using this dollar value per calorie, GOP calculated the value of the service provided by wetlands. They state:

> "To estimate the dollar value of an acre of marsh based on the energy/money conversion...we need only to multiply the round figure productivity estimates by 1850 kcal/lb. to get kcal/acre...and divide by 10^4 kcal/dollar to get dollars/acre. Such a calculation gives a value of $4,070/year for the marsh as a whole.... The income capitalized value would be $81,400 per acre overall when discounted at a five percent interest rate" [6, p. 20].

The Fallacy

In order to gain an appreciation of the implications of the life support methodology, it would be useful to apply it to valuation of services which have comparable market values. Using the life support methodology to value hay land in Virginia results in an estimate of $6,960 per acre.[47] Yet, the average price of farm land, including buildings in Virginia, was $556 in 1974 [25]. Also using this life support approach, the annual value of an acre of forest was estimated to be $10,360 per year [18], and using a five percent discount rate, the present value of an acre of forest land would then be $207,200. Clearly these land value estimates appear to be inflated when measured by the test of existing land market prices for agricultural and forest land.

The proponents of the life support methodology recognize this:

> This value may be regarded as somewhat inflated by egocentric man, since he might not consider all work done by a forest as useful to man. However, we believe it comes closer to the real value than conventional cost-accounting which value forests only in terms of yield of wood or other consumer products and ignores its life-support values [18, p. 184].

While the values do appear "somewhat inflated," it is not certain that this is because "egocentric man" does not recognize the "real value" of resources in "conventional cost-accounting". Rather, the discrepancy between observed market values and those estimated by the life support methodology may be explained by the failure of its proponents to recognize how prices and GNP will be a function of the relative money prices of goods; prices which bear only a partial and inconsistent relationship to the energy content of goods being traded. The money level of GNP, as that measure is actually developed, does not depend only upon energy as the source of money value. To imply that "prices are ultimately determined by energy" does an injustice to economic science. To attempt to value calories as proposed above does an injustice to the important contribution ecological system analysis can make to resource decision making.

Energy and Economic Value

Acceptance of the life-support methodology requires acceptance of two implications of the methodology: (1) the ultimate objective of society is to maximize net energy, and (2) the economic system will seek this energy goal through a mechanism which ties market prices for goods to the energy necessary for their production. This conclusion has been rigorously demonstrated by Huettner [8]. Indeed, Huettner finds that only if maximum net energy were the goal of an economic system would the prices of all goods be determined by their energy content. Conversely, if maximum net energy is not the goal of economic systems, then prices must reflect considerations other than the energy content of the goods they represent. Therefore, insofar as relative prices of products (which are the basis for calculation of GNP) do not reflect energy alone, then the imputation of all GNP to calorie use following the life-support methodology is fallacious. This point can be clarified by considering the argument in more detail.

The goal of economic systems, according to a standard definition, is to allocate resources among competing uses to satisfy human wants [10]. A market system is one particular form of economic organization which, through the generation of prices, assists individual consumers and producers in making resource allocation decisions. This information role for price is based upon the ability of relative prices to direct resource use in such a manner that markets will clear, and that incentives will be provided to increase or decrease use of particular factors of production and of goods and services, and that new technology will be developed in accordance with changing consumer demands and input costs.

Could prices based upon energy content efficiently direct resource use in the manner described above? The system of "energy based" prices suggests that all goods and services, as well as inputs such as labor, machinery, and raw materials, are merely transformed energy. As such, we live in a one commodity (calories) world. In this world, energy becomes the only relevant constraint on production and consumption, and prices function to allocate within the energy constraints. To understand the implications for economic processes of this assertion, consider a starting equilibrium situation where a given product, x, is defined in terms of its net energy content, and the price of x is a direct function of that embodied energy. If a shift in demand occurred for x, the market system would seek to allocate both existing stocks of x and plant capacity available to product x, via a rise in the price of x. This price rise must be independent of the net energy content of both the stock of x and the plant capacity to produce x. This is clearly correct since the embodied energy content of the stock of x and the plant capacity has obviously not changed. As Huettner notes:

> "A short-term deviation from energy content pricing would be socially useful since it would indicate that something has increased in relative scarcity and is a constraint (at least temporarily), that consumers should conserve it and find substitutues and that producers should search out new supplies. If market prices [based upon relative scarcity] are not allowed to prevail then non-market actions such as government rationing and production incentives would be required [Huettner, p. 103].

The reason prices must reflect relative scarcity, as opposed to energy content, becomes especially clear if one considers the market system in its greater complexity. In both the long and short run, demand and supply shifts are constantly occurring, necessitating relative price variations for resource allocation that are independent of energy content; one cannot synthesize all other resource inputs from energy since many characteristics of some factors of production (water and skilled labor, for example) are not useful in the production process because of energy content; finally, the adjustment periods for market prices to ration existing production and to encourage changes in production levels are of variable length between commodities requiring a variable time length for deviations from energy content pricing. As Huettner concludes:

> Non-energy inputs are indeed constraints and energy content pricing...[is] hopelessly inappropriate and inefficient for short-term or long-term decision-making. The important point is that the world is full of relative scarcities and always will be. A price or value theory that ignores this fact by assuming that all inputs are merely transformed energy and that energy is the only constraint would be unworkable. Markets would not clear; investment, resource allocation, and other decisions would be distorted; and real income would be suboptimized ...since prices determined by energy content alone were not designed to accomplish these objectives. Net energy, however, would be maximized [8, p. 103].

In short, the economic system could not perform its social function of resource allocation if prices were determined only by energy.[5/] Therefore, since prices are not determined solely by energy content,[6/] one must conclude that prices and calories are not directly linked in the manner GOP suggest.[7/]

Market Prices, Market Failure and Technical Remedies

Market prices emerge from the market exchange process as a function of both demand and supply phenomena. The basis of this price determination system is that prices are determined by exchange process "at the margin" and a market price for any commodity is determined by the marginal values consumers place on that resource in terms of their own judgment about its present and future uses.[8/] Rejection of revealed market prices as measures of social value may be based upon two criteria: (1) rejection of the market system objective of satisfying revealed human wants; or (2) rejection of the functioning of the existing market system.

The first criticism focuses on the wisdom of resource use directed by existing human preferences. Within a market-exchange economy, individuals reveal preferences (and values) for particular configurations of resource use over space and time. Such preferences are reflected in market prices which direct resource use. As Boulding has observed:

> Economics, as such, does not contribute very much to the formal study of human learning...our main contribution as economists is the description of what is learned; the preference functions which embody what is learned in regard to values, and the production functions which describe the results of the learning of technology [1, p. 4].

Critical judgments about the process which reveals learned value might focus upon the irrationality or ignorance of individuals. Of course, this criticism is not a criticism of the market mechanisms ability to reveal existing values, but rather it is a condemnation of those values as judged by some external standard. Such an external standard might be a preceived need to maximize net energy in allocating resources. For, as has been noted above, even a perfect market would not maximize net energy.[9/]

A second criticism of market directed resource use points to the inability of the existing market systems to actually promote economic goals, and identify meaningful economic values through exchange since the exchange process often is subject to flaws.

> ...there are many cases where exchanges occur without money passing hands; where exchanges occur but they are not freely entered into; where exchanges are so constrained by institutional rules that it would be dubious to infer that the terms were satisfactory; and where imperfections in the donditions of exchange would lead us to conclude that the price ratios do not reflect appropriate social judgments about values. Each of these cases give rise to deficiencies in the use of existing price data as the basis of evaluation of inputs or putputs [11, p. 534].

One goal in coastal wetlands management has been for researchers to develop methods to assign monetary values to the services of natural wetlands where no market or only limited market information exists. Such values must be derived by reference to man's revealed preferences for particular resource uses. While there are numerous technical questions to be dealt with in this effort, the basis for economic value is a reference to man's use as reflected in revealed preferences [11, 13].

In this context, agricultural land in Virginia is valued in the market at $556 per acre and not $6,990 as the life-support methodology suggests. Perhaps there exist some non-market services of value that such land provides (recreation, open space); perhaps the current price fails to reflect future demands for agricultural land; and, as such, perhaps $556 per acre understates the value of such land. Still, one does not attempt to correct for market exchange failure problems in dollar evaluations by failing to recognize and utilize the essential premise of revealed human preferences to derive appropriate values. The existence of market failure and its subsequent impact on price determination does not justify naive melding of dollars with calories as a remedy. Yet, it is exactly this

approach which the proponents of the life-support methodology utilized to correct for market failure. It is naive melding that is used by GOP to justify an $82,000/acre wetland value estimate, and as such that value should be questioned. Although there is reason to further refine our understanding of long-term relationships between energy and economic activity [5, 24], these are very different considerations than the proposed conversion of calories to dollars.

OTHER APPROACHES FOR ESTIMATING WETLAND VALUES

Accurate value estimates of specific natural marsh services may be developed using proper application of economic principles. Indeed, GOP made such attempts, although numerous errors can be found in the methodology used.[10/] The purpose of the following discussion is not to directly demonstrate, in step by step fashion, how proper economic analysis would be done. Rather, by critiquing the GOP use of economic tools, several points can be made that can serve as "red flags" to those analysts who would seek to improve economic analysis of natural wetlands.

Appeal to Market Information: The Value of Wetlands as a Fish Nursery and in Oyster Production

Natural wetlands are productive of marine life and as such, one demand for natural wetlands is derived from the demand for seafood and sport fishing. GOP's calculation of the contribution of wetlands to the value of sport and commercial fishing found that wetlands acres add an average annual value of approximately $100 per acre to fisheries. This is equivalent to a $2,000 per acre present value when valued at a five percent discount rate. GOP obtained this figure by adding together the annual dockside value of fish products landed, annual value added in seafood processing, and total annual expenditures by saltwater fishermen, and then dividing by total acres of wetlands. There are numerous conceptual errors in this approach.

First, the methodology assumes that any loss in total fish population due to marsh destruction will directly appear as reduced marketable fish harvest. However, fish catch depends upon population base (biomass and size distribution) and fishing effort. If, for example, marshlands are not at maximum carrying capacity, some marsh destruction may not result in reduced fish population. Further, if there is reduced fish population, the same average effort expended may result in fewer fish harvested, but that link needs to be directly estimated to successfully tie fish population to fish harvest.

Second, the GOP calculations imply that all wetlands acres are equally productive of fish. By dividing total expenditures by total acres to gain an estimate of an average value of marshland fish production, the methodology implies that there is no difference between marsh acres in their productive capability. Adequate analysis can only be accomplished if this variability is explicity considered.

Third, the values gained or lost cannot often be appropriately measured by resort to total market revenue such as dockside value of fish lands. In fact, if the loss in fish population due to marsh destruction results in a leftward shift in the supply curve of fish harvested, and, if this occurred in the inelastic range of the demand curve, total dockside value of fish would rise, not fall. This would suggest a negative value to marsh acres if GOP's reasoning were applied. Properly conducted economic analysis, however, is careful to recognize a distinction between market exchange prices and broader definitions of social value based upon economic surplus argument.[11/] [13].

Finally, the most serious error in the GOP approach is their failure to properly recognize the principle of with and without analysis. Anytime the

values gained or lost by changes in resource use are calculated, the reference should be to the value of the resource with the change as compared to the value without the change. One can discover two serious violations of with and without analysis in the GOP methodology.

In the first instance, GOP imputed all the values to be derived from the recreational and commercial fisheries to wetland acreage, which is tantamount to arguing that without any wetland acreage there would be no fisheries. However, even if every acre of wetland were filled, some commercial and recreational fishing activity would remain viable. The analysis should identify the difference in fishery values with wetlands and compare those to values of the fishery without wetlands.

A second violation of the with and without principle is in the assumption that the whole market value of the fishery is attributable to the wetlands.[12] For the commercial fisheries, this implies that the market price of fish products does not bear any relation to the labor and capital costs in fish harvesting and processing. Specifically, it implies that the value of these resources in the fishing industry is zero, and that if the fishery were to cease to exist, there would be no market value for the human and capital resources used in the commercial fishery. The proper with and without calculation would compare the returns to labor and capital used in the fishing industry with the returns those resources would earn in their next best employment alternative if the fishery ceased to exist. This difference is the economic loss as a result of the fishery ceasing to exist because all wetlands were filled.[13]

The same error is made in the procedure of allocating all expenditures of salt water sport fishermen to wetlands. Allocating expenditures of sportsmen to wetland acres neglects the fact that even if all salt water fishing were lost, recreationists would direct expenditures elsewhere. Obviously this would be the recreationists' second choice, but total expenditures on salt water fishing overestimates the recreationist's loss in value due to switching from salt water fishing to the second choice. GOP do recognize this allocation error, but do not deal with it properly.

GOP estimate the value of a wetlands acre for oyster production by considering its potential for development of "intensive aquaculture" [6]. They note that well managed oyster grounds produce oyster meat with an annual market value of $630 to $1,575, and have a present value of $12,600 to $31,500. Then, they argue that all marshland should be capable of producing this value of oysters and infer that all marsh is therefore worth at least this value. The arguments made above about the problems with the GOP calculated fishery values apply here as well. Specifically, this approach implies that if all wetlands produced oysters for market that the market price would remain unaffected; and, that all the market value returns to oysters and none to labor and capital.

Alternative Cost Methods: Value of Wetlands in Waste Assimilation

GOP used an alternative cost method for evaluating a wetlands' value in waste assimilation. This method suggests that the estimated value of the

service can be approximated by the cost of the next-best alternative way to providing that service, and is conceptually correct if properly applied. GOP used the alternative cost approach by arguing that estuarine waters are capable of providing the equivalent of tertiary treatment that would otherwise be provided through treatment plants at a cost of $2,500 per year. Therefore, they calculated that an acre of wetlands providing similar waste assimilation is worth $2,500 per year or a present value of $50,000 [6, p. 21]. However, the use of alternative cost estimates should be governed by three considerations: (1) the alternative considered should provide the same services; (2) the alternative selected for the cost comparison should be the least-cost alternative; and (3) there should be substantial evidence that the service would be demanded by society if it were provided by that least-cost alternative. GOP failed to subject their estimate to any of these important tests.

The first problem ignored by GOP was whether the level of waste treatment they used as the alternative would be provided by all wetlands. For example, they noted that almost 400 pounds of phosphorous could be removed from sewerage each year by an acre of marsh, at a cost saving of $480 per year when compared to cost of treatment plant removal. However, if the marsh acre does not receive any waste load, then no dollar benefits for waste assimilation exist. Further, it is unlikely that all marshes, regardless of location, provide the same waste assimilation services, that is, the removal of 400 pounds of phosphorous per year. Yet, this is what GOP implied by their methodology. To properly apply the approach, the waste assimilation provided by particular acres of marsh must be determined.

Second, GOP did not demonstrate that the waste treatment technology they used for their alternative is in fact the least cost available. For example, they used the cost of tertiary waste treatment of Lake Tahoe, Nevada, for their estimate of tertiary treatment costs. Perhaps a combination of land treatment, changes in production technologies, and different waste treatment technology would be less expensive. This is not to suggest that it would be, but the estimates GOP provided did not even recognize this issue.

A third serious flaw in GOP's use of the alternative costs technique was their implicit assumption that the demand for advanced waste treatment in fact exists; in short, that the added social value from the cleaner water exceeds the costs of obtaining that cleaner water. The costs associated with the removal of each unit of additional waste (marginal cost of treatment) can be characterized as sharply increasing, particularly for tertiary treatment [9]. The implicit assumption of GOP was that these sharply increased costs provide additional natural values for which society would be willing to pay, since they use the costs of alternative waste treatment systems that provide primary, secondary and tertiary treatment as their alternative cost comparison.[14/]

However, what value would society receive from tertiary treatment? The burden of proof lies with those who would argue that the alternative costs method does accurately reflect willingness-to-pay for tertiary treatment.

GOP offered no evidence on this question, but rather sought to defend their estimate.

> "Some people would raise the issue whether or not this work would be done at all if payment were necessary, and therefore whether it is appropriate to evaluate the marsh's work on such a basis. The answer is obvious. Without such treatment, accelerated pollution accumulation would soon exact payment, either through direct payment or indirect means, such as increased medical costs, loss of recreational areas, loss of fisheries, etc." [6, p. 11].

However, even here, GOP only reinforced the conclusion that they are unaware of the pitfalls of the alternative cost approach. In this quote, they again imply that the values lost through some degradation in the physical environment (ex. reduction in recreational areas) are greater than the costs of achieving these benefits. The argument was offered as a proof of the value of marshland, when in fact it is not a proof, but rather must itself be subject to tests of proof.[15]

CONCLUSION

Given the current policy setting, it is appropriate, useful, and long overdue that researchers should attempt to establish values associated with services eminating from natural wetlands. In this respect the study by GOP provides a useful focus for this effort. However, GOP have not provided us with conceptually sound estimates of economic value. The type of results reported by GOP can only inhibit the application of proper evaluation techniques.

There are two fundamental problems with the GOP approach. First, GOP failed to recognize the nature of the process by which economic values are determined, and made an illegitimate marriage of the principles of systems ecology with economic theory. This failure makes the values calculated for "total life-support" meaningless for conceptually correct economic comparisons of development and preservation. Second, where GOP attempted to apply proper economic principles, they made numerous errors (many of which they recongize, but subsequently ignore) which result in estimates of economic values of natural marshland which are clearly in error. As such, GOP's estimates of the value of marsh services are, at best, inaccurate. At worst, these inaccurate estimates may capture the attention of policy debate and hinder, rather than improve, the resource management process for coastal wetlands.

FOOTNOTES

1. Some authors suggest that estimates of values of wetlands in alternative uses are not necessary or desirable for decision making, and reject existing economic, legal, and social institutions which currently form the basis of quantitative value estimates. Thus, they argue, "Why is it that aesthetics, or wilderness values, or a sense of responsibility for all living things are not sufficient of themselves to legitimize wetlands preservation? Why must we always trot out scientific or economic 'proof' for propositions that any person can understand and judge for himself" [28, p. 232]. Such a perspective seems to contradict the well established tradition of quantitative evaluation of alternatives found in natural resource decision making.

2. This is clearly a simplified view of a more complex argument. However, the basic outline above captures the flavor of the Odum argument, and indeed of much of the work of systems ecology in general. For example, in discussing the potential of harvesting plant material from the sea for feeding expanding human population, Watt argues, "The difficulty with this possibility is that much of the world's sea plant material is low density populations of algae; we might expend more energy sieving this out of vast quantities of sea water than we obtain energy from the process [net energy criterion], and energy, not money, will be the coin of the realm for human populations within a few decades [29, p. 17].

3. It is not clear from the available literature exactly what data base is used in the calculation of the ratio. In addition, although there is some recognition that this ratio will vary between different parts of the economy, there is not recognition that it will also vary over time. However, the exact magnitude of the ratio of the fact that it has fallen over time (i.e., less energy use per dollar of GNP) need not be of concern here [24].

4. This estimate was obtained by using the money-energy conversion figure supplied by GOP and the kcal/hectare values obtained from Pimentel [22]:

$$R = \$/10^4 \text{ kcal} \times \frac{8.6 \times 10^6 \text{kcal}}{\text{hectare}} \times \frac{\text{hectare}}{2.47 \text{ acres}} = \$348 \text{ acre/year}$$

   Discounting this figure at 5% with the formula, PV = R/i, yields $348/.05 or $6,960.

5. The idea of a "factor-of-production theory of price determination" is not new to economic science. Classical economists devoted much of their time to establishing a link between particular factors of production (land, labor) and market price. In this energy theory

of price determination, we see a resurrection of a similar economic value theory which has long ago been discarded as a useful explanation for market exchange prices. As with its predecessors, the energy theory of value is unenlightening in explaining how exchange values (prices) are determined. As one critic of the energy approach has noted, "the reason a Rembrandt painting is more valuable than a Picasso drawing is not because oil paint contains more BTU's than ink" [21].

6. This argument does not suggest that energy use and prices are unrelated. Changes in consumption and production patterns for all products and production inputs will respond to prices as well as other demand and supply variables. Such changes will result in alterations of the level and types of use to which resources are put, and, therefore, determine calorie use in society. In short, prices determine energy use levels, not the reverse; and, total energy use will vary over time and over space as well as between products in time and space. Even if technology is assumed unchanging, the level of energy use in a society is ultimately price and market dependent. For more discussion see Huettner [8].

7. Note that this argument does not suggest whether maximum net energy should be the criterion of social value. It only asks if it, in fact, is the current criterion of value in the economic system.

8. Much debate has focused upon the basis for utility (preference) judgments made by individuals. Whether one views the calculation of utility by the individual in terms of Benthamite pleasure-pain calculus, or some broader based assessment of moral values, the fact remains that exchange prices still reveal utility to man. For an early discussion of this point, see Myrdal [14].

9. An excellent example of this type of criticism is made by Walker. He suggests that if one disagrees with values which emerge from existing economic and social pressures, it is not appropriate to simply misstate the economic values to make the answer come out right. With respect to wetland values, he observes that, "Real change (in wetlands use-value) requires a major revolution in human values and the legal and social organization society" [28, p. 23].

10. GOP's study [6] and Pope and Gosselink's application of the GOP study [23] did ostensibly recognize many of the methodological issues raised below. Yet, once recognizing them, they proceeded to ignore the implications. For example, Pope and Gosselink argue that the monetary values "determined on the basis of [a]....special [wetland] use is not applicable to marshland in general," yet in the same article justify the general life-support value of $82,000 as realistic because it is roughly equivalent to the sum of the values they calculate for special uses[23].

11. GOP recognize the need to consider economic surplus [6, p. 3] although they misapply the concept since they refer to consumer willingness-to-pay (consumer surplus) for fish products when they should also

be concerned with the economic rent value of marsh acreage (producer's surplus).

12. This is a common error. See for example Metzgar [12].

13. GOP justified allocating the total value to wetlands by arguing that "conventional economics" is equally in error since it would attribute a zero value to the fish and hence the wetlands. This argument is a misreading of the economic literature. Economists have long argued that the tendency for the value of the fish resource to be driven to zero in a market context is an example of market failure arising from common property problems in the fishery. That is, the zero market value on the fish resource is not condoned by conventional economics as GOP imply, but is cited as a classic example of market failure[7].

14. One can see the possible fallacy of this assumption by reference to an example. Assume that an acre of wetland can produce a ton of marine worms per year. Further, assume that a ton of marine worms could be artificially propogated in a laboratory at a cost of $100,000. Could we then conclude that wetlands services which produce a ton of marine worms are worth $100,000 to society? The answer is no, unless we can convincingly demonstrate that society would be willing to pay $100,000 per ton for marine worms.

15. One particular waste assimilation benefit of marshland ignored by GOP, and by this discussion, is the assimilation of waste from non-point discharges. The cost of control of these wastes may be quite high and the alternative of natural wetlands as a treatment source may be quite valuable.

16. Marginal value refers to the value of an additional acre filled or preserved; average values are calculated by dividing the total value of all wetland acres in a particular state of development by the total number of such acres.

REFERENCES

[1] Boulding, Kenneth, "Economics as a Moral Science" American Economic Review, Vol. 59, #2, pp. 1-12, May 1969.

[2] Carlson, Gerald A., "A Review of Public Demand for Rural Land Rights", p. 79-89, in Land Use Needs and Policy Alternatives, Proceedings of Workshop on Land Use, Southern Land Economics Research Committee, (ed.) Howard A. Clonts, SRDC Series, Pub. No. 1, Mississippi State, Mississippi, August 1976.

[3] Council on Environmental Quality, Environmental Quality - 1974, (Washington: U.S. Government Printing Office, 1974).

[4] Department of Defense, Department of the Army, Engineer Corps, "Regulatory Program of the Corps of Engineers", Federal Register, July 19, 1977.

[5] Georgescu-Roegen, Nicholas, "Energy and Economic Myths", Southern Economic Journal, Vol. 41, No. 3, January, 1975, pp. 347-381.

[6] Gosselink, James G., Odum, Eugene P., and Pope, R. M., The Value of the Tidal Marsh, Publication No. LSU-SG-74-03, Center for Wetland Resources, Louisiana State University, Baton Rouge, Louisiana, May 1974.

[7] Haveman, Robert H., "Common Property, Congestion and Environmental Pollution", Quarterly Journal of Economics, Vol. 87, No. 73, pp. 278-287.

[8] Huettner, David A., "Net Energy Analysis: An Economic Assessment", Science, Vol. 192, April 9, 1976, pp. 101-104.

[9] Kneese, A. V. and Bower, B. T., Managing Water Quality, Economics, Technology, Institutions, (Baltimore; John Hopkins Press, 1973).

[10] Mansfield, Edwin, Microeconomics, (New York: W. W. Norton and Company, December 1976).

[11] Margolis, Julius, "Shadow Prices for Incorrect or Nonexistent Market Values", The Analysis and Evaluation of Public Expenditures: The PPB System, U.S. Congress, Joint Economic Committee, U.S. Government Printing Office, Washington, D.C., 1969, pp. 553-546.

[12] Metzgar, Roy G., Wetlands in Maryland, Maryland Department of State Planning, Pub. No. 157, Baltimore, Maryland, September 1973.

[13] Mishan, E. J., Cost-Benefit Analysis: An Introduction, (New York: Praeger Publishers, 1971).

[14] Myrdal, Gunnar, The Political Element in the Development of Economic Theory, (New York: Simon and Shuster, 1969).

[15] Odum, Eugene P., "A Description and Value Assessment of South Atlantic and Gulf Marshalnd Estuaries", Proceedings: Fish and Wildlife Values of the Estuarine Habitat, Bureau of Sport Fish and Wildlife, Atlanta, Georgia, 1973.

[16] Odum, Eugene P., "Pricing the Natural Environment", Research Reporter, University of Georgia, Fall 1975.

[17] Odum, Eugene P., "The Emergence of Ecology as a New Integrative Discipline", Science, Vol. 195, March 25, 1977, pp. 1289-1293.

[18] Odum, Eugune P., and H. T. Odum, "Natural Areas as Necessary Components of Man's Total Environment", Transactions of the North American Wildlife and Natural Resources Conference, 1972, pp. 178-189.

[19] Odum, Howard T., Environment, Power, and Society, (New York: John Wiley & Sons, Inc., 1971).

[20] Odum, Howard and Odum, Elizabeth, Energy Basis for Man and Nature, (New York: McGraw Hill, 1976).

[21] Pesking, Henry M., "Letter", Science, Vol. 192, April 2, 1976. p. 11.

[22] Pimentel, David, W. Dritshilo, J. Krummel and J. Kutzman, "Energy and Land Constraints in Food Protein Production", Science, Vol. 190, November 21, 1975, pp. 754-761.

[23] Pope, R. M. and Gosselink, James, "A Tool for Use in Making Land Management Decisions Involving Tidal Marshland", Coastal Zone Management Journal, Vol. 1, No. 1, pp. 65-74, 1973.

[24] Shurr, Sam H. and Darmsteder, Joel, "The Energy Connection", Resources, (Washington, D.C.: Resources for the Future, Fall 1976).

[25] U.S. Department of Commerce, Bureau of the Census, 1974 Census of Agriculture, Preliminary Report, Virginia, (August 1976).

[26] U.S. Senate Committee on Public Works, Hearings, "Section 404 of the Federal Water Pollution Control Act Amendments of 1972", U.S. Government Printing Office, Washington, D.C., Serial No. 94-H49, July 27-28, 1976.

[27] Virginia Code Ann.

[28] Walker, Richard A., "Wetlands Preservation and Management: A Rejoinder-Economics, Science and Beyond", Coastal Zone Management Journal, Vol. 1, No. 2, pp. 227-236, Winter, 1974.

[29] Watt, Kenneth, Ecology and Resource Management, (New York: McGraw Hill, 1968).