

ECONOMIC INCENTIVES FOR INSTITUTIONAL  
CHANGE; THE CASE OF THE VIRGINIA  
WETLANDS ACT

by

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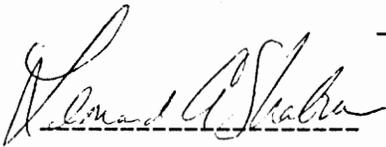
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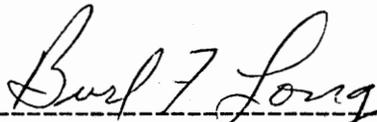
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## CHAPTER I

### INTRODUCTION

#### The Problem

In April 1972 the General Assembly of Virginia passed the Virginia Wetlands Act, declaring it to be the public policy of the Commonwealth of Virginia to preserve the coastal wetlands of Virginia and to accommodate necessary economic development in a manner consistent with wetlands preservation.

In addition to general policy and standards to apply to decisions regarding wetlands, the Act provides a zoning ordinance which localities must adopt in order to exercise authority over local wetlands. The wetlands zoning ordinance provides that any proposed alteration of wetlands requires a permit from a local wetlands board. If localities fail to adopt the required ordinance, all activities involving wetlands alteration require a permit from the Virginia Marine Resources Commission (VMRC).

The Virginia wetlands program is based on the premise that wetlands constitute an irreplaceable natural resource essential to existing ecological systems, and this premise is reflected in the standards pertaining to the use and development of wetlands:

- (1) Wetlands of primary ecological significance shall not be altered so that the ecological systems in the wetlands are unreasonably disturbed;
- (2) Development in Tidewater Virginia, to the maximum extent possible, shall be concentrated in wetlands of lesser ecological significance, in wetlands which have been irreversibly disturbed before July 1, 1972, and in areas of Tidewater Virginia apart from the wetlands.<sup>1</sup>

Wetlands contribute to fisheries propagation. The vegetation of marshes in the tidal reaches of Virginia enters the food web of marine species in the Chesapeake Bay. Scientists estimate that 90 percent of all fish landed in Virginia waters depend upon marshes for their existence at some time during their life cycle.<sup>2</sup> Wetlands have also been credited with other beneficial natural functions, such as providing cover for certain waterfowl and fur-bearing mammals. Marshes serve as buffers against the effects of storm tides, retard shore erosion, and help prevent saltwater intrusion into inland freshwater aquifers.

About 95 percent of Virginia wetlands are in private ownership. Because wetland owners cannot appropriate the benefits derived from ecological services of wetlands, these benefits do not enter the decision calculus of private land use decision-makers. Decisions to dredge, fill and develop marshlands are not constrained by the cost

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<sup>1</sup> Va. Code Ann., sec. 62.1 - 13.1 et seq. (1973) (Supp. 1976).

<sup>2</sup> Marvin L. Wass and Thomas D. Wright, Coastal Wetlands of Virginia, Special Report in Applied Marine Science and Ocean Engineering, No. 10 (Gloucester Point, Virginia: Virginia Institute of Marine Science, 1969), abstract, p. vii.

of the ecological benefits that will be foregone if the wetlands are altered.

The wetland market can be characterized as having elements of market failure. The Virginia Wetlands Act is a response to this perceived market failure and can be considered an attempt to provide consideration of the ecological values accruing to society from wetlands in their natural state.

Like other land use legislation, the Virginia Wetlands Act represents a form of institutional change. Institutions in this case refer to sets of decision rules, created through the political process, which control resource allocation decisions. The institutional arrangements prior to implementation of the Virginia Wetlands Act were characterized by private ownership of most wetlands acreages. Disposition of wetlands acreages was subject to the allocative functions of real estate markets, and decisions concerning use were left primarily to private owner-decision-makers.

A question with important policy implications is why a change was advocated in Virginia's wetlands institutions. Like other proposals for institutional change, the Virginia Wetlands Act was passed in response to dissatisfaction with the performance of existing land use institutions. Market failure in the allocation of ecological services of wetlands can be demonstrated. Yet markets have always failed to consider ecological values of wetlands. Demonstration of market failure does not explain why wetlands legislation passed in 1972 rather than at some other time.

A better understanding of why change is demanded in institutions for resource allocation is important to people who are ultimately responsible for deciding whether institutions should be changed by political process and, if so, what type of change is warranted.

To determine why demand for institutional change occurs requires an approach to institutions which treats them as endogenous to the larger, social, political, and economic system. Such an approach requires a larger concept of the economic domain than that adhered to by neoclassical economists. It suggests the need for a general theory of institutional change.

#### The Schultz Hypothesis

Schultz, recognizing the importance of understanding how and why institutions change, proposed a theory which treats institutions as variables which respond to the dynamics of economic growth.<sup>3</sup> Schultz defines an institution as a behavioral rule pertaining to social, political, and economic behavior. Although he recognizes that not all institutional changes can be treated as a response to economic growth, he asserts that a large and important set can be treated analytically in this manner.

Schultz introduces two concepts which are essential to his view of institutional change: a) the economic value of the function performed by an institution, and b) the concept of economic equilibrium

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<sup>3</sup>T. W. Schultz, "Institutions and the Rising Economic Value of Man," American Journal of Agricultural Economics, L (December 1968), pp. 1113-1122.

with respect to services of institutions.<sup>4</sup> If each institution is necessary to the provision of some service, and if there is demand for the service, it is therefore within the province of economic theory to approach the determination of the economic value of each service by supply-demand analysis. Placing this supply-demand approach into an equilibrium framework requires the key assumption that the economy reaches an equilibrium with respect to the economic services of institutions when rates of return represented by these and other services reach equality.

In Schultz' view, consequences of the modern economic growth process includes all manner of disequilibria, including disequilibrium in the supply and demand of economic services provided by institutions.<sup>5</sup> It is this disequilibrium which stimulates pressure for institutional change.

Among the institutions that render services to the economy, Schultz lists those that establish the framework for the production and distribution of public goods.<sup>6</sup> Normally private markets fail to produce public goods because the non-exclusion and nonappropriability

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<sup>4</sup>Ibid., pp. 1116-1117.

<sup>5</sup>Ibid., p. 1117.

<sup>6</sup>Ibid., p. 1114.

implied by the Samuelsonian definition would discourage production by profit maximizing resource owners.<sup>7</sup>

Extending Schultz' view, much environmental legislation over the past few years represents institutional change to assure provision of valued, though unmarketable, amenities and services of natural environments. The timing of the institutional change, given failure of existing arrangements to provide for environmental services, is explainable in terms of increases in the value of benefits from environmental amenities relative to the value of those development uses of natural environments which are favored by private market allocation but which destroy the ecological productivity of natural environments. As benefits from natural environments begin to exceed benefits from development activities, incentive exists to advocate changes in institutions so that the higher preservation benefits can be captured.

It is significant for Schultz' view of institutional change that institutions created or changed by political decisions have certain characteristics of a Samuelsonian public good. Assume, as Schultz does, that institutional change is sought because it will benefit all or some portion of the population. Assume further that the probability that a given institutional change will be made is proportional to the time and resources expended in lobbying for

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<sup>7</sup>Paul A. Samuelson, "The Pure Theory of Public Expenditure," Review of Economics and Statistics, XXXVI (November 1954), pp. 387-389.

change. However, once the institutional change has been implemented, its benefits and costs will accrue to members of the population without particular reference to the expenditures made by individuals in behalf of lobbying efforts. Thus, an individual in a group organized for the purpose of lobbying for institutional change cannot be expected to believe that his own failure to cooperate would substantially jeopardize his prospects of enjoying the fruits of institutional change.<sup>8</sup> Only when the expected benefits to each individual are quite high relative to personal costs of lobbying for institutional change would individuals be expected to forego an opportunity for a "free ride" and taken an initiative in lobbying for the institutional change. This implies that the social benefits to be captured by institutional change must exceed the benefits from existing arrangements by a substantial amount before active pressures for change will be applied.

A complete empirical verification of Schultz' hypothesis concerning demand for institutional change would be a vast and expensive task, given the complexities of institutional interaction and the difficulty of acquiring sufficient relevant data. However, the case of the Virginia Wetlands Act offers an excellent opportunity to explore the view that institutional change in that instance occurred in response to the dynamics of economic growth.

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<sup>8</sup>Mancur Olson, Jr. The Logic of Collective Action: Public Goods and the Theory of Groups (Cambridge: Harvard University Press, 1965), pp. 9-13.

### Objectives

It is the purpose of this study to develop further insight into how and why institutions change, with particular reference to change in Virginia's wetlands institutions.

The following general research objectives will be pursued:

1. to identify the sources of value imputed to unaltered ecologically productive wetlands,
2. to identify sources of value imputed to wetlands altered for development purposes, and
3. to estimate rates of increase over time in preservation values and development values imputed to wetlands.

### Hypothesis

A strong hypothesis, in the case of the Virginia Wetlands Act, would be that preservation values of wetlands, recognized by institutional change, grew to exceed the value of benefits imputed to wetlands in development. A test of this hypothesis would require measurement of actual levels of preservation values, a task which would require resources in excess of those available for this study.

This study addresses the hypothesis that institutional change, in the case of the Virginia Wetlands Act, was associated with an increase in the perceived value of social benefits from wetlands preservation, relative to the value of social benefits from those development uses of wetlands which destroy their ecological productivity.

Contents

Chapter II presents a more detailed discussion of economic institutions and decisionmaking for institutional change. The Schultz hypothesis as it relates to the Virginia wetlands example will be refined, and research objectives will be specified in greater detail.

Chapter III develops a theoretical framework, based upon economic rent theory, for defining and measuring rents attributable to wetlands as residential sites. Land value comparisons employing regression analysis will be used to derive a measure of the annual rate of increase in market-imputed values to wetlands in development.

Chapter IV examines several sources of value imputed to unaltered, ecologically productive wetlands. Estimates are made of the annual rate of increase in the value of benefits imputed to wetlands from recreational sport fishing and from commercial food fish.

Chapter V will report conclusions, and discuss their implications for explaining institutional change and for public policy. Limitations of the analysis and of the implications will also be presented, along with several suggestions for further research.

## CHAPTER II

### INSTITUTIONAL CHANGE: THE CASE OF VIRGINIA'S WETLANDS LEGISLATION

It has been argued that changes in the economy make new demands on institutions over time.<sup>1</sup> Accordingly, some forms of institutional change may represent a response to shifting demand for the services provided by institutions. If institutions change in response to economic change, economic theory can play a role in explaining sources of demand for institutional change and the timing of pressures for institutional change. This chapter explores theoretical and conceptual considerations underlying these assertions, examines their relevance for institutional change in the administration of wetlands resources, and refines a hypothesis concerning the causes of change in Virginia's wetlands institutions.

#### Toward an Overview of Political and Economic Institutions and Their Interrelatedness

An attempt to understand and assess institutions and institutional change, to articulate a problem setting suggesting research opportunities relative to institutional change, requires a clear and unambiguous concept of institutions and of relations among

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<sup>1</sup>T. W. Schultz, "Institutions and the Rising Economic Value of Man," American Journal of Agricultural Economics, L (December 1968), p. 1113.

institutions. A purpose of this section is to develop a perspective on the relationships between political decision institutions and institutions for resource allocation.

### Institutions Defined

Institutions are variously defined. John R. Commons defined institutions as "collective action in restraint, liberation and expansion of individual action."<sup>2</sup> Institutions defined in terms of rules indicate what:

"...individuals must or must not do (compulsion of duty), what they may do without interference from other individuals (permission or liberty), what they can do with the aid of collective power (capacity or right), and what they cannot expect the collective power to do in their behalf (incapacity or exposure)."<sup>3</sup>

Wantrup imputes a purpose to institutions when he defines them as social decision systems that provide "...decision rules for adjusting and accommodating over time, conflicting demands (using the word in its more general sense) from different interest groups in a society."<sup>4</sup>

Schmid defines institutions as "...sets of ordered relationships among people which define their rights, exposure to the

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<sup>2</sup>John R. Commons, Institutional Economics (New York: The MacMillan Company, 1934), p. 73.

<sup>3</sup>John R. Commons, Legal Foundations of Capitalism (New York, The MacMillan Company, 1924), p. 6.

<sup>4</sup>S. V. Ciriacy-Wantrup, "Natural Resources in Economic Growth: The Role of Institutions and Policies," American Journal of Agricultural Economics, LI (December 1969), p. 1319.

rights of others, privileges, and responsibilities."<sup>5</sup> Schmid's definition is consistent with the other two and will not be elaborated further.

Schultz defines an institution as a behavioral rule; pertaining to social, political, and economic behavior.<sup>6</sup> He offers, as examples, rules that govern marriage and divorce, rules embodied in constitutions that prescribe the allocation and use of political power, and rules that establish market capitalism or specify government allocations of resources and distribution of income.

#### Economic Institutions and Property Rights

Rules that establish market capitalism, or specify government allocation of resources and of income, define economic institutions. More generally economic institutions are conceptualized as social decision systems which provide decision rules both for the use of resources and for the distribution of the income stream derived from such use.<sup>7</sup>

Although variously defined, property rights describe the relation among people, often with respect to the use of goods or services but more generally with respect to the expectations one individual

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<sup>5</sup>A. Allan Schmid, "Analytical Institutional Economics: Challenging Problems in the Economics of Resources for a New Environment," American Journal of Agricultural Economics, LIV (December, 1972), p. 893.

<sup>6</sup>Schultz, op. cit., p. 1114.

<sup>7</sup>Wantrup, op. cit., p. 1320.

may reasonably hold in his dealings with others.<sup>8</sup> Among other things, property rights designate who may appropriate benefits derived from a particular resource or other property object, terms under which a property object may be used, and under which rights to it may be transferred.

For purposes of providing analytical perspective, reference can be made to the concept of a "non-attenuated structure of rights." This structure of rights has the following characteristics.<sup>9</sup>

- (a) the set of rights is completely specified. That is, relationships, entitlements, restrictions, and obligations are specified for all transactors and transactions and with respect to all possible property objects, (resources or goods and services derived from them),
- (b) exclusive rights must be specified, so that all rewards and penalties accruing from an action accrue to the actor,
- (c) the set of rights must be enforceable and enforced, and
- (d) rights must be transferable.

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<sup>8</sup> H. Demsetz, "Toward a Theory of Property Rights," American Economic Review, LVII (May, 1967), pp. 347-359, reprinted in Eirik G. Furubotn and Svetozar Pejovich, The Economics of Property Rights, (Cambridge, Mass.: Ballinger Publishing Company, 1974), p. 31.

<sup>9</sup> Alan Randall, "Property Rights and Social Microeconomics," Natural Resources Journal, XV (October, 1975), p. 733.

The institutional structure based upon a non-attenuated system of rights is consistent with, and necessary for, the concept of perfect markets. Although the perfect market is an analytical "ideal" form of economic organization, it is probably the most thoroughly modeled and best understood theoretical form of economic organization studied by economists.

Given the assumption of a non-attenuated structure of rights and certain other assumptions defining competitive conditions, welfare theorists have logically extended neoclassical microeconomics to show a correspondence between competitive equilibrium and Pareto efficiency.

This concept of efficiency generated by perfect competition in the institutional context of non-attenuated property rights provides useful point of reference in later discussion. Specifically, it can be shown that the political process, through which institutions change, may respond to criteria other than that of efficiency. In addition, the unique nature of some resources or environmental amenities may preclude specification of a non-attenuated structure of rights in them, thus creating problems for their efficient allocation.

#### Political Decisionmaking For Change in Economic Institutions

Definitions of institutions have been cited which treat them as sets of behavioral rules. Economic institutions and the structure and conduct of economic organization are conditioned by the

definition and distribution of property rights. Market economies rely generally upon private ownership and exchange of property. Perfect markets rely on a non-attenuated structure of rights. The concept of economic efficiency is defined on the performance of perfectly competitive markets. Therefore, decisions concerning property rights have important welfare implications.

Rights are defined and enforced by government. Government ultimately performs in accordance with behavioral rules embodied by political institutions. Therefore, institutions controlling resource allocation can change through the political process which, in turn, is controlled by political institutions. A hierarchy of decision institutions exists.

Wantrup's attempts to conceptualize problems in water research can be extended to decisions concerning the use of natural resources.<sup>10</sup>

From the standpoint of decision theory, institutions for resource allocation may be regarded as sets of decision rules in a multi-stage decision process. In this process, a sequence of decisions extends over time and space in an "open" system (or perhaps a closed system of tremendous complexity). The system in the control of which decision rules are sought is partly natural, environmental-ecological; within which human-oriented activities of production, consumption, and exchange occur. Decision rules are wanted which

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<sup>10</sup>S. V. Ciriacy-Wantrup, "Water Policy and Economic Optimizing: Some Conceptual Problems in Water Research," American Economic Review, LVII (May, 1967), pp. 179-189.

resolve conflicts among users, between private users and government, among government users, and between "nature" and human uses.

To find decision rules for an integrated resources system, we may differentiate (at least) three levels of decisionmaking, called "the hierarchy of decision levels."

On the first level, the lowest, the decisionmaking process related directly to the control of inputs, outputs, and other quantitative characteristics of the resource system. The operating sectors are both private and public, and both may accommodate or condition the operations of nature. Decision rules for this level specify maximization of an objective function under constraints imposed by institutions, technology, and resource availability, achieved by satisfying necessary and sufficient conditions as represented by the calculus of variations. Dissatisfaction with either the allocation or the distribution of resources, or of the goods in the production of which they are used, is sufficient to motivate efforts to change the institutions or rules to which private (or public) lower level decisionmaking has been subjected. Such rule changes are made at the second level of this decisionmaking hierarchy.

Decisionmaking at the second level controls the institutional framework of the decision process at the first level. Decisionmaking at this second level is by political process and cannot be relied upon to solve ad hoc the many technical difficulties of quantitative optimizing. Social decisionmaking at the second level treats as variables those institutions which serve as constraints at the

first level. The purpose of decisionmaking on the second level is not to control directly inputs, outputs, and other quantitative characteristics of resource use patterns nor to obtain a path of quantitative welfare optima at various points in time under projected conditions for these points.

Under the constitutional organization of the United States, the second level of decisionmaking occurs within the legislative, judicial and executive branches of government. Within the second level of decisionmaking are hierarchies of authority -- federal, state and local. The powers of the respective branches tend to be residual powers -- those not pre-empted at higher levels.

The third decision level is represented by the constitutional organization of the United States.<sup>11</sup> It was adopted almost 200 years ago, complete with prescribed procedures for altering its provisions. It created the legislative, executive, and judicial branches and prescribed their duties, responsibilities, and prerogatives. It also defined the distinctions between local, state, and federal levels within each branch, specifying which powers are retained at the federal level and which are delegated to lower levels. The constitution also contains a list of rights retained by individuals which may not be usurped by government and which serve as constraints on government activities.

The constitutional organization of the United States, with its emphasis on individual liberties, no doubt conditions the nature of

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<sup>11</sup>Ibid., p. 183.

decisions made by the various authorized units of government with respect to institutional arrangements for the allocation of resources. Specifically, there is presumption in favor of market allocation.

In the Wantrup categories of decisionmaking, problems in resource use can be viewed as resulting in efforts by citizenry to invoke the powers and processes at the second level of decisionmaking to affect changes in rules by which lower level decisions are made, in such a manner as to satisfy needs or wants not currently satisfied.

#### Institutional Response to Economic Change

The Wantrup hierarchy of decision levels are useful for the insights they provide into the relationships among political decisions, institutional change, economic organization, and resource allocation. They are not sufficient, however, as explanations for why change is wanted in established institutions. They do not identify dynamic factors in the political and economic systems which generate political pressures for institutional change. They do not aid in predicting when pressure for institutional change will evolve nor in which sectors of the economy the pressures will be most intense.

It was noted in Chapter I that Schultz, recognizing the importance of understanding how and why institutions change, proposed a theory which treats institutions as variables which respond to the dynamics of economic growth.<sup>12</sup> Schultz recognized that not all examples of institutional change can be treated thus, but he asserted

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<sup>12</sup>Schultz, op. cit., pp. 1113-1122.

that a large and important set can be treated analytically in this manner.

Two concepts are essential to Schultz' view of institutional change: a) the economic value of the function performed by an institution, and b) the concept of economic equilibrium with respect to institutions.<sup>13</sup> If each institution is necessary to the provision of some service, and if there is demand for the service, it is therefore within the province of economic theory to approach the determination of the economic value of each service by supply-demand analysis. Placing this supply-demand approach into an equilibrium framework requires the key assumption that the economy reaches an equilibrium with respect to the economic services of institutions when rates of return represented by these and other services reach equality.

In Schultz' view, consequences of the modern economic growth process include all manner of disequilibria, including disequilibrium in the supply and demand of economic services provided by institutions.<sup>14</sup>

In this context it must be remembered that the political process of decisionmaking for institutional change is not costless. While political lobbyists or decision-makers may disregard the consequence of their decisions for others, they cannot ignore the costs to themselves of lobbying or the political costs of an unpopular decision.

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<sup>13</sup> Ibid., p. 1116.

<sup>14</sup> Ibid., p. 1117.

It is this costliness of decisionmaking for institutional change which lends an added measure of plausibility to the concept of an equilibrium with respect to the services of institutions.

Given the cost of collective action for institutional change, sufficient incentive must exist to overcome the political inertia behind existing institutional arrangements if change is to occur. It is this assertion which underlies Schultz' hypothesis that the dynamics of economic growth are responsible for disequilibrium in the supply and demand of services provided by institutions.

A further consideration lending plausibility to the Schultz hypothesis stems from the "public good" nature of institutional change. If lobbying efforts are successful in promoting institutional change, the additional social benefits made possible by institutional change are typically available without reference to individual contributions to the lobbying efforts.

The implication is that the benefits made possible by institutional change, accruing equally to all individuals, must be sufficient in magnitude that any one individual would be willing to bear a major share of lobbying costs in order to assure availability of those benefits to himself, even though he may expect most other non-excludible beneficiaries to "free ride." Given that the aggregate demand for public goods is the vertical summation of individual demand curves, total social benefits from institutional change will probably be quite large compared to social benefits from arrangements existing before institutional change occurs.

In terms of Schultz' hypothesis, the public goods nature of institutional change will require a substantial difference between social returns to institutional change and that to existing institutions before concerted lobbying for change will be forthcoming.

This study presents the changes in Virginia's wetlands institutions as a problem setting in which to explore research opportunities suggested by Schultz with respect to institutional change.

Ecological Services, Market Failures, and Incentives for Institutional Change: The Wetlands of Virginia

This section is devoted to a description of institutional change in the case of the Virginia Wetlands Act, identifying services associated with the change, services associated with pre-existing arrangements, the role of perceptions in popular evaluation of benefits and costs, and a restatement of the Schultz hypothesis.

Ecological Services of Wetlands

Scientific evidence indicates that vegetation found in tidal salt marshes is an essential component of the food-web of which marine species sought by commercial fishermen are a part and upon which they are dependent. More specifically, an estimated 90% of all fish landed in Virginia waters depend upon marshes for their existence at some time during their life cycles.<sup>15</sup> Vegetation from tidal marshes in decayed form, is fed upon by microscopic organisms which, in turn, become food for larger organisms until finally fish are

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<sup>15</sup>George M. Doves and Claiborne Jones, "Virginia Wetlands Law," Impact, Richmond, Va., The Council on the Environment, (September, 1975), p. 1.

feeding on small plants and animals which are visible to the naked eye. Marsh vegetation also provides shelter for juvenile fishes and are known to be productive fish-spawning and nursery grounds.

Tidal marshes aid in maintaining water quality by filtering out sediment from upland sources.<sup>16</sup> Clairity of water, which marshlands contribute to, is essential to many forms of marine life.

Salt marsh vegetation had a dense root structure which binds soil and peat, protecting shorelines from erosion. Salt marsh root systems produce peat, which functions like a giant sponge. This quality enables marshes to absorb large amounts of water quickly and release it slowly, thereby reducing the effects of coastal flooding caused by storms or unusually high tides.<sup>17</sup>

Marsh vegetation is a protective habitat for a variety of marsh-dwelling birds and other animals. Of importance to sport fowlers is the use of wetlands by migratory geese and ducks in the winter months.

#### Competing Uses for Wetlands

In addition to their productivity as part of the natural ecology, some wetlands in Virginia have economic value as sites for waterfront development. Such commercial or residential uses of wetlands areas tend to be destructive of their ecological productivity,

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<sup>16</sup>Ibid.

<sup>17</sup>Ibid.

involving, as they often do, dredging, filling, and draining of areas with marsh vegetation.

A 1969 study<sup>18</sup> reported that 4,026 acres of wetlands, or 1.2% of Virginia's total wetlands had been lost as waterfowl habitat between 1954 and 1969 due to encroachment by human activities. In 1969, tidal wetlands in Virginia were estimated at 319,614 acres. Ecologically productive wetlands were being lost at an increasing rate over time, with only 106.7 acres per year being lost in the 1955-59 period, as compared to 451 acres per year in 1965-69.<sup>19</sup>

Channelization accounted for 47% of wetland acreage loss. Residential development accounted for 27% of the loss, industry for 17%, with roads, docks and marinas, and other causes accounting for the remaining 9%.<sup>20</sup>

#### Market Failure in Ecological Services of Wetlands

In an earlier section it was noted that a system of perfectly competitive markets, predicted on a "non-attenuated" structure of property rights, would function in such a manner as to allocate resources to their highest-valued use. In reality, of course, the specification and enforcement of property rights cannot always be

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<sup>18</sup> Fairfax Healy Settle, Survey and Analysis of Changes Effected by Man on Tidal Wetlands of Virginia, 1955-1969 (Masters thesis, Virginia Polytechnic Institute and State University, Department of Wildlife Management, December, 1969), p. 13.

<sup>19</sup> Ibid., p. 23.

<sup>20</sup> Ibid., p. 23.

"non-attenuated." This is especially true in the case of the ecological services rendered by tidal wetlands.

Because of the nature of wetlands (and to some extent, land in general) activities on one parcel of land enter the utility or production functions of those residing elsewhere; directly, rather than through markets. In particular, the ecological services of tidal marshes as the source of food and as spawning grounds for marine species serve as inputs in the natural production of commercially valuable edible sport fish. The owner of wetlands, by choosing not to destroy marshes in favor of some incompatible use of the site, has assured a continuing flow of ecological services from the marsh which benefit sports and commercial fishermen who may live miles away.

This physical interdependency of tidal marshland with other parts of the environment gives rise to certain public goods aspects of wetlands.<sup>21</sup> Generally speaking, the role of salt marshes in the marine food web is essential to maintenance of commercially valuable marine species. Benefits derived from salt marshes which are available for one fisherman are equally available to any and all fishermen who care to fish. (Of course, over-fishing can reduce fish populations, so that the availability of benefits diminishes beyond some point.) The owners of tidal marshlands cannot appropriate the

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<sup>21</sup>Recall that jointness in supply characterizes Samuelson's public good. Once produced, any given unit of the good can be made equally available to all, and consumption by one individual does not limit or reduce consumption by any other. Paul A. Samuelson, "The Pure Theory of Public Expenditure," Review of Economics and Statistics, XXXVI (November 1954), pp. 387-389.

benefits to fishermen that accrue from the preservation of ecologically productive marshes.

Normally, it would be expected that private markets would fail to produce public goods because the non-exclusion and non-appropriability implied by the Samuelsonian definition would discourage production by profit maximizing entrepreneurs. In the case of wetlands, the fact that these ecological services are available at all stems from the fact of their natural origin. These services of wetlands continue to flow until or unless demand for alternative uses of the marsh site is sufficient to justify alteration of the site for some conventional commercial use. Wetlands owners cannot appropriate compensation from beneficiaries for "producing" ecological services necessary for the fisheries industry. Therefore, they will assure the continued production of these services only if their own preferences justify it, or if ecological benefits are produced as a coincidental by-product of other commercial activity on the land.

Failure of markets to assure continued "production" of the ecological services of tidal wetlands would be inconsequential if there were no competing demands for wetlands acreages. However, evidence has been sited of wetlands destruction to accommodate commercial and residential uses of the wetlands sites.<sup>22</sup>

Even the existence of incompatible competing uses of wetlands would be of minor importance if the effects of wetlands destruction

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<sup>22</sup>Settle, op. cit., p. 23.

were easily reversible. However, once wetlands are drained and filled in, they cannot be replaced in the short run. Technology cannot yet duplicate complex ecological systems, at least not at costs supportable by the current value of commercial products derived from them. Uncertainty as to the exact nature of biological linkages which would clarify what acreage and location of marshland is necessary to sustain a given population level of marine species, coupled with the possibility that wetlands destruction may result in the extinction of some biological species, with the consequent loss of biological information entailed, are arguments for wetlands preservation.

#### The Schultz Hypothesis Restated

Failure of markets to account for ecological benefits of marshlands, even given competing uses for them and the practical irreversibility of their destruction, still does not explain the pressures which were brought to bear for institutional change to assure wetlands protection. Private markets have never accounted for the ecological benefits of wetlands. That institutional change should occur in 1972 instead of at some other time could be attributable to dynamic interrelationships which have increased the perceived importance of ecologically productive wetlands to some politically influential segment of the population. In terms of Schultz' hypothesis, it could be asserted that perceived benefits from preservation are increasing over time relative to perceived benefits from development of wetlands.

The Schultz hypothesis can be formalized by borrowing notation used by Krutilla and Cicchetti in their Hell's Canyon study.<sup>23</sup> Consider the annual benefits over time from a given asset, say an acre of wetlands.<sup>24</sup>

$$b_t = b_o (1 + \alpha)^t$$

where:

$b_t$  = benefit in year  $t$ ,

$b_o$  = benefit in the base year, and

$\alpha$  = the annual rate of change in  $b$ .

If the demand for the service of wetlands is increasing over time, given a fixed, non-augmentable supply of wetlands, then  $\alpha$  is greater than zero. If  $\alpha > 0$ , then  $b_t > b_o$ .

The annual benefit will change over time as indicated in the diagram of Figure 1.

The Schultz hypothesis can be restated in terms of the relative values for  $\alpha$  for preservation uses of wetlands as compared to development uses of wetlands:

$$H_o: \alpha_p > \alpha_d$$

where:

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<sup>23</sup> John V. Krutilla and Charles J. Cicchetti, "Evaluating Benefits of Environmental Resources with Special Application to the Hell's Canyon," Natural Resources Journal, XII (January, 1972), pp. 4-8.

<sup>24</sup> Ibid., p. 10. The value of service consumed per unit of time is measured by the area under the demand schedule. When the facility providing the service is a reusable, non-depreciating asset, such as an undisturbed natural environment, the value of benefits is the area under the demand curve for each period time the area is used.

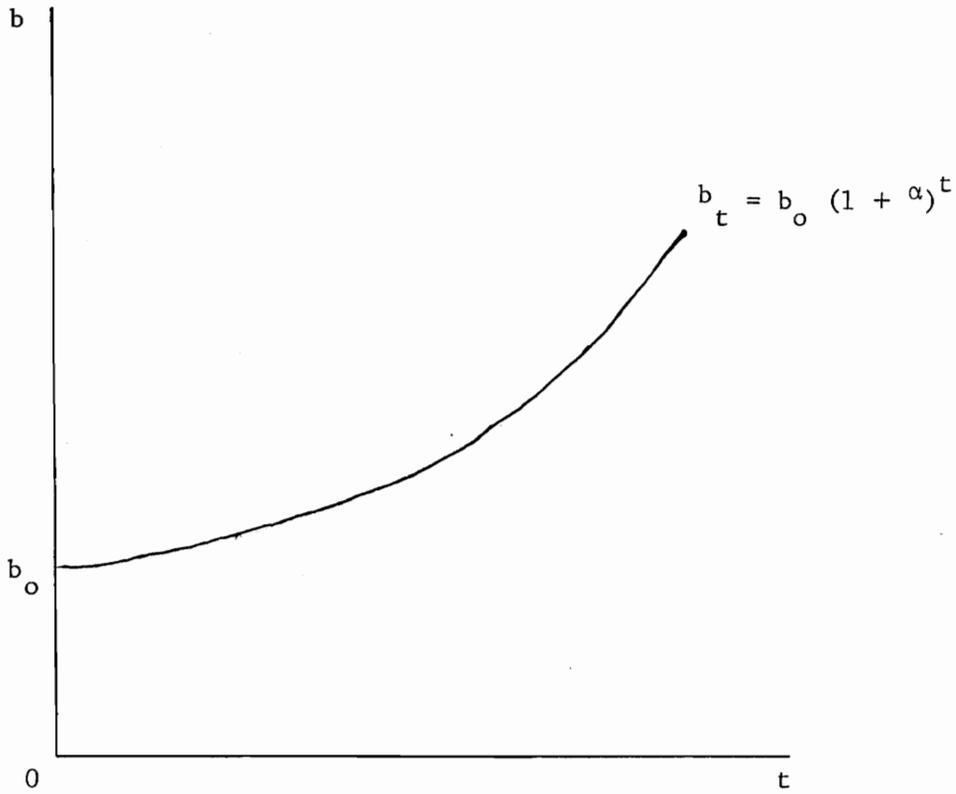


Figure 1. Time Pattern of Annual Benefits Derived from an Acre of Wetlands.

$\alpha_p$  = the annual rate of change in the value of ecological benefits of wetlands, and

$\alpha_d$  = the annual rate of change in the value of development uses of wetlands.

This hypothesis is illustrated graphically in Figure 2. The hypothesis asserts that because  $\alpha_p$  is greater than  $\alpha_d$ , perceived benefits to society from the wetlands ecology have been increasing more rapidly than net social benefits attributable to wetlands as sites for development. At some time, probably before 1972, benefits from preservation began to exceed benefits from development. Existing institutional arrangements failed to permit appropriation of these greater benefits. Thus, incentives existed for political activities designed to assure institutional change to protect wetlands from further destruction.

In the context of this hypothesis, the public good nature of the services provided by ecologically productive wetlands assures the public good nature of benefits from institutional change in this instance. It is significant that preservation of natural environments entails all of the problems of organizing for the provision of public goods. Potential purchasers of options can be expected to bide time in the expectation that others will meet the necessary costs, thus eliminating cost to themselves. Since the existence or provision of environmental services for one individual renders them equally available, without excludability, to others; a collective effort to provide for environmental preservation may fail for lack of support. Provision of environmental amenities, because of jointness in supply and nonexcludability, suffers from free rider problems.

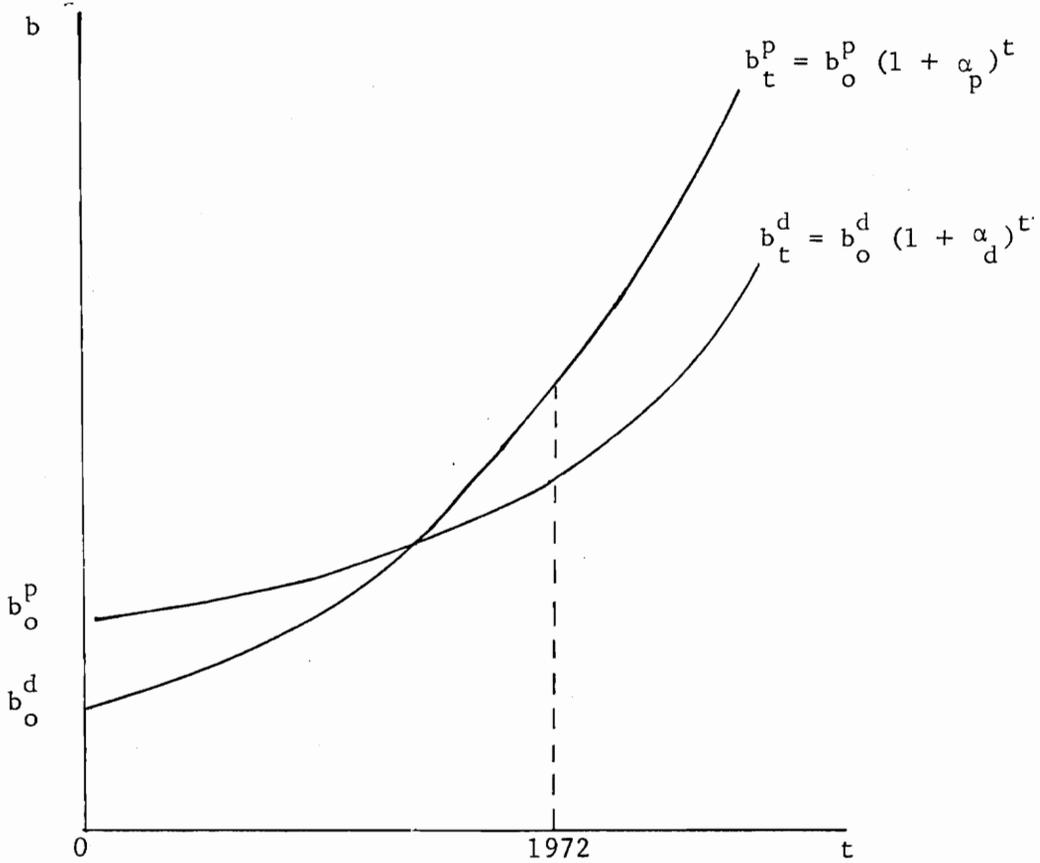


Figure 2. Hypothesis: Time Rate of Change in Preservation Benefits ( $\alpha_p$ ), Exceeds Time Rate of Change in Development Benefits ( $\alpha_d$ ), and:  $b_o^P$  = benefits from preservation, base period;  $b_t^P$  = benefits from preservation, year t;  $b_o^d$  = benefits from development, base period; and  $b_t^d$  = benefits from development, year t.

Instead of striving for private negotiation to assure preservation of natural environments, collective action may consist of efforts to induce governments to take action favored by the lobbying group. In this manner, private collectives can divest themselves of the transactions cost which would otherwise result from efforts to reach agreement among numerous landowners and numerous non-owners in the resolution of conflicts over the use of natural environments.

However, as was discussed in an earlier section, lobbying efforts are themselves costly. Benefits made possible by legislation protecting wetlands are available without reference to individual contributions to the lobbying efforts.

In terms of Schultz' hypothesis, the public goods nature of benefits from institutional change will require a substantial difference between the social return to preservation and that to development before concerned lobbying for protective legislation will be forthcoming.

#### Importance of Public Perceptions

Schultz' hypothesis would suggest that the social rate of return attributable to wetlands ecology has increased at a faster rate than has the social rate of return to wetlands as sites for development, and that, for a politically influential portion of the population, the expected benefits flowing from wetlands given institutional change (the Virginia Wetlands Act) exceed expected benefits from development uses.

It is not sufficient, nor is it even strictly necessary, that actual benefits from preservation increase more rapidly (or exceed) actual social benefits from development. It is necessary and sufficient that a politically influential portion of the electorate perceive that benefits to be captured through institutional change exceed benefits to be realized through development uses of wetlands.

Some indication of the nature of public perceptions of ecological versus development benefits can be gained by reviewing transcripts of public hearings held in four localities throughout Virginia during October 1971, by the Virginia Wetlands Study Commission prior to drafting of legislation.<sup>25</sup> Although proponents of protective legislation did not speak with one voice, there was consistency in the perceptions of proponents regarding sources of ecological benefits of wetlands and in the sense of urgency with which the need for protective legislation was expressed.

Repeated reference was made to the importance of salt marshes to recreational fish as well as to the commercial fishery.<sup>26</sup> Objection was voiced to "Venice type of development" each of which "cuts the productive potential of the marshes, and if enough of these areas are developed, the fishing that attracts many will be greatly diminished, not only for these people, but for the rest of the public."

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<sup>25</sup>Copies of the transcripts, and of letters and documents included in the record, are available on microfilm from the Division of Statutory Research and Drafting Studies, Virginia Advisory Legislative Council and Select Committee, Virginia State Library, Division of Records Management, Richmond, Virginia.

<sup>26</sup>See, for example, a letter of October 10, 1971 to the Wetlands Study Commission from Ira M. Gabrielson.

Another example of this view is as follows:

"the dependence of commercial and sport fishing on wetlands is dramatically - and tragically - illustrated by the decline in fish catches that has accompanied the rapid destruction of wetlands in recent years.<sup>27</sup> Between 1955 and 1965, the catch of estuarine dependent fish off the Atlantic and Gulf states has dropped from 393 million pounds to 291 million. In the last five years of that period, commercial catches of eighteen Atlantic species declined by as much as 50%. The importance of these figures to Virginia's economy is pointed up by the fact that nearly 95% of the state's total annual catch of fish, commercial and sport, are estuarine dependent."

In addition to the belief that the values of commercial and sport fisheries are dependent on wetlands acreages, the conviction was expressed that failure to enact protective legislation would result in rapid and extensive destruction of marshes. The tradition of private wetlands ownership and allocation . . .

"...caused such things as the irreversible destruction of 20% of Virginia's wetlands and 50% of Connecticut's"<sup>28</sup>

"I feel that [a] zoning solution will be forced upon us in any event, in a context of desperate reaction to crises . . ."

"The swamps' use [under zoning] could be mostly classified to remain as it is. Otherwise its character as we know it, will continue to become altered and will eventually disappear."

In other testimony, an Interim Report on Wetlands by the Virginia Institute of Marine Science, 1969 was cited:

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<sup>27</sup>October 8, 1971, Statement to the Virginia Wetlands Study Commission on Behalf of the Audubon Naturalist Society of the Central Atlantic States, by William A. Houston.

<sup>28</sup>Letter to Russell M. Carneal, Chairman, Wetlands Study Commission, from Thomas M. Rowe, December 3, 1971.

If measures were not taken soon:

"there exists a strong possibility that a unique resource which would be held beyond price or any economic means of reckoning by future generations, will be lost to the Commonwealth and its people."<sup>29</sup>

The opinion was voiced at one hearing, by a candidate for the State Senate, that in the next twenty to thirty years all the wetlands of Virginia would be destroyed unless some legislative action was taken at once.<sup>30</sup>

If these examples of public testimony are taken as representative of the perceptions of proponents of protective wetlands legislation, several implications seems clear:

- 1) Proponents of wetlands legislation felt that social benefits lost through development uses destructive of wetlands exceeded benefits to society from development.
- 2) Proponents of wetlands protection attached the same high value to every acre of wetlands, without perceiving the possible low value of marginal acres.
- 3) Wetlands ecology was implicitly credited with the total value of commercial and sport fisheries.
- 4) Wetlands left undisturbed would continue to be productive indefinitely, with a high probability that their value would increase with time.

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<sup>29</sup>October 8, 1971, Statement by Ted Pankowski, Co-Chairman of the Wetlands Committee for the Conservation Council of Virginia, before the Wetlands Study Commission, Arlington County Courthouse.

<sup>30</sup>October 13, 1971, Minutes of the Virginia Wetlands Study Commission, Arlington County Courthouse, p. 6.

- 5) Without legislative intervention, all ecological values of wetlands would eventually be lost forever.

Again, however, a relevant question would be to inquire why members of the public were willing to lobby for protective legislation in 1972 rather than at some earlier or later period. To the extent that perceived benefits from alternative uses of wetlands are based upon actual benefits, then a measure of actual benefits would serve as information with which to test the hypothesis of Figure 2. If other values are generally perceived to be valid indicators of relative benefits, then relevant measures for the test of the hypothesis would be based upon those values perceived to be valid.

#### The Problem for Empirical Research

The Virginia Wetlands Act is an example of a change in a land use institution. The change occurred through second-level decisions in the political arena. Prior to the change, wetlands were allocated to alternative uses through first-level decisions of private landowners. However, some of the ecological services of the wetlands are characterized by certain aspects of public goods, making it impossible for non-attenuated property rights to be vested in them. The result was failure of markets to force consideration of the ecological value of undisturbed wetlands in private decisions to develop wetlands. That is, there was market failure in the allocation of ecological services of wetlands.

However, there has always been market failure in the ecological services of wetlands. A problem for research is to determine why change occurred when it did.

The approach to institutional change represented by the interpretation of Schultz' hypothesis presented in this chapter has intuitive appeal. If it is correct, it will help explain both the timing and the intent of activities directed toward institutional change.

A problem for empirical research is to estimate or approximate values for  $\alpha_p$ ,  $\alpha_d$ ,  $b_o^d$  and  $b_o^p$ . Measures of these values would reveal whether or not benefits from preservation of wetlands increased in value over time at a faster rate than benefits from development uses of wetlands, so that in some year benefits from preservation of wetlands began to exceed benefits from development of wetlands, creating an incentive to lobby for institutional change to capture the larger preservation benefits.

Unfortunately, resources required to estimate levels of benefits attributable to preservation of wetlands would exceed those available for this study. Therefore, this study will estimate values for  $\alpha_p$  and  $\alpha_d$  to test the weaker, although related, hypothesis that  $\alpha_p$  was greater than  $\alpha_d$  with respect to the value of benefits derived from Virginia's wetlands. The weaker hypothesis must hold true in order for the stronger hypothesis to be accepted in the case of institutional change represented by the Virginia Wetlands Act of 1972.

Chapter III presents a theoretical framework for identifying a measure of the value of wetlands in development uses and a basis for calculating the time rate of change in annual rents attributable to

wetlands in development as an approximation of  $\alpha_d$ . The last part of Chapter III presents results of an attempt to empirically estimate  $\alpha_d$ . Chapter IV presents theoretical and empirical findings relevant to the estimation of  $\alpha_p$ , the time rate of change in benefits imputed to ecological productivity of wetlands.

Chapter V presents an overall summary of findings, and a discussion of conclusions and implications to be inferred from those findings.

## CHAPTER III

### CHANGING VALUES FOR DEVELOPMENT USES OF WETLANDS

#### Introduction

Observed development activities on coastal wetlands in Virginia indicate that most development demand for wetlands is derived from the demand for waterfront residential sites. The practice of draining and filling marshes, and of dredging channels through marshes to achieve open water access to adjacent upland residential sites indicates that the development alternative for wetlands is based upon the demand for site advantages of waterfront or channelfront location, and is not related to such factors as the type or density of vegetation to be found on the site.

This chapter comprises a study which seeks to measure changes in the benefits from residential uses of wetlands. A measure of the value of a characteristic of certain land parcels is needed. The market value of such characteristics as channelfront location cannot be observed directly because the characteristics, like land itself, are distinct from capital and labor insofar as they are immobile. A characteristic of land cannot be moved in order to capture a higher market value. The characteristic may be attributed only with that portion of value in production or consumption which remains after payments are made to non-land factors necessary to capture or use the site

characteristic, and to other characteristics of the land which contribute to its productivity.

In competitive land markets we would expect sellers to accept no less and buyers to pay no more than the expected present value, in dollar terms, of annual rents over the productive life of the parcel of land in its intended use. A measure of the market value of a particular characteristic, then, would be the difference between the market price of a parcel possessing the characteristic and another parcel not possessing the characteristic, all other factors being equal.

If market price differentials attributable to amenities associated with channelfront location in Virginia's wetlands can be isolated, and if changes in this differential are observed over time, then a measure of the time range of change in benefits attributable to development of wetlands can be computed. The measurement of such differentials in land values, if they exist, is the objective of the study reported in this chapter.

#### Determinants of Land Prices

This section presents a graphic illustration of the relationship between land rents and price determination for residential property. This illustration will facilitate conceptualization of expected property value differentials resulting from situation of a residential site on a channel instead of away from the water.

### Land Rent and the Market Value of Land

Assume that capital, measured in dollars per year, is the only nonland input and that it is being combined with a parcel of land of a known fixed size. Assume that the variable input, capital, exhibits declining marginal productivity, so that the total physical product increases at a decreasing rate. (See Figure 3, a and b.)<sup>1</sup>

The value of the marginal product (VMP) represents the return in cents per year to marginal dollars of capital investment. Therefore, values on the vertical axis of Figure 3, c, are expressed as percentages. The VMP curve is equivalent to a marginal efficiency of capital schedule. Points on the schedule represent the marginal rate of return,  $r$ , of capital applied to a parcel of land of a fixed size.

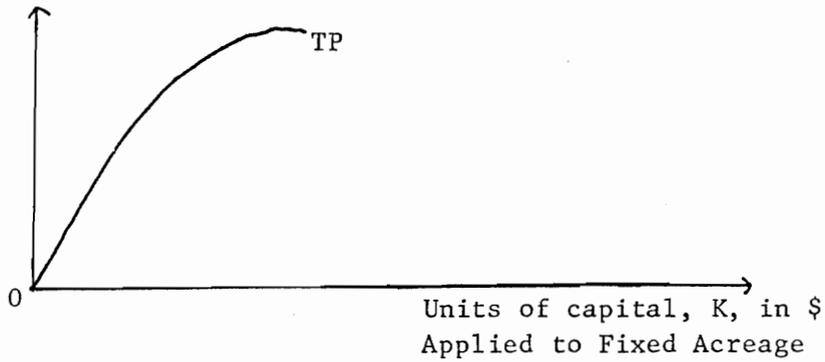
Since the vertical axis represents percentages, the area under the VMP curve corresponds to a fraction of the money sum shown on the horizontal. Thus, the VMP curve can be used to show changes in money returns, with total returns per time period represented by the area under the VMP curve from the origin to the point on the horizontal axis corresponding to the units of capital applied to the fixed acreage of land in the production process.

The marginal rate of return to capital is comparable to the market rate of interest. If the market rate of interest ( $i$ ) is taken to be the cost per dollar of capital, then  $i$  is the marginal factor cost of capital ( $MFC_k$ ).

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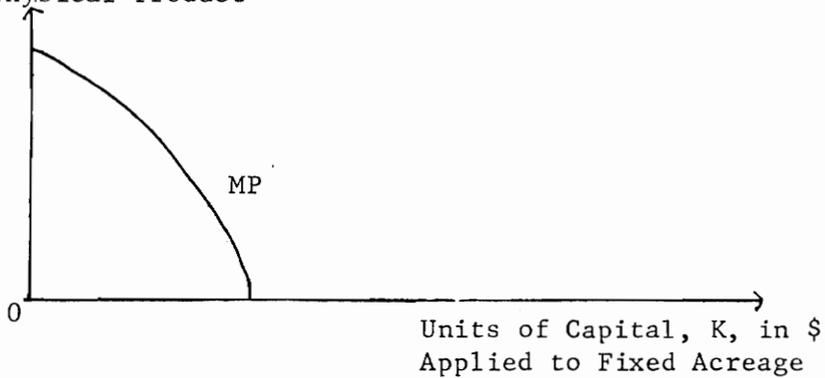
<sup>1</sup>Actually, Figure 3 depicts a production relationship wherein the marginal productivity of capital is declining and eventually becomes negative. This is assumed for the ease of exposition which results from having a marginal productivity curve which intersects both axes.

Units of Physical Product



- a. Relationship of Total physical Product, TP, to the level of Capital, in Dollar Units Per Time Period, Applied to a Parcel of Land of Fixed Size.

Units of Physical Product



- b. Relationship of Marginal Physical Product, MP, to the Level of Capital, in Dollar Units Per Time Period, Applied to a Parcel of Land of Fixed Size.

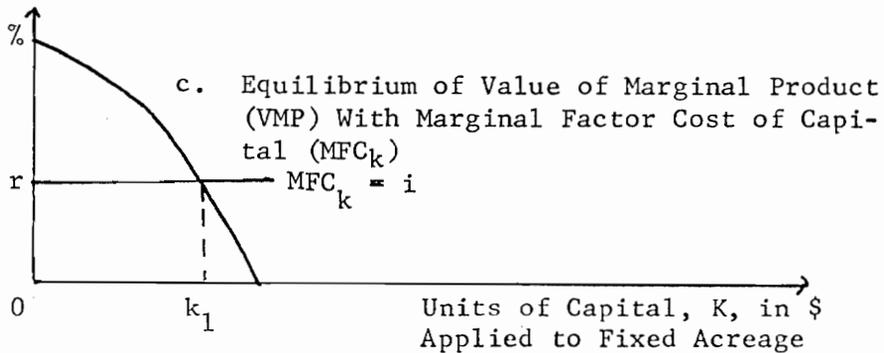


Figure 3. Derivation of Marginal Rates of Return Per Time Period to Capital Applied to a Fixed Acreage of land, all Other Inputs Held Constant.

At the level of capital,  $K_1$  (see Figure 3, c), the marginal factor cost,  $MFC_k$  equals the value of the marginal product VMP. Since  $MFC_k$  is equivalent to the market rate of interest,  $i$ , and since points on the VMP curve are equivalent to the marginal rates of return to capital,  $r$ , then  $i = r$  at the equilibrium level of investment,  $K_1$ , of capital in dollars per time period applied to a parcel of land of fixed size. That this equality is an equilibrium is demonstrated in paragraphs to follow.

Assume a market rate of interest equal to  $i_1$ , (Figure 4). The profit maximizing level of capital investment on the given parcel of land is  $OK_1$ . That is, the profit maximizing level of capital investment on the parcel of land is that level at which VMP in percentages equals the market rate of interest. At levels of investment less than  $OK_1$ , such as  $OK_2$ , the rate of return per dollar invested,  $r_2$ , is greater than the market rate of interest,  $i_1$ , signaling higher levels of investment. At levels of investment greater than  $OK_3$ , the rate of return per dollar of capital invested is less than the opportunity cost of capital. In this case a lower level of capital investment is indicated.

At  $OK_1$ , total returns per time period on the given land parcel are  $OABK_1$ . Of this total, area  $Oi_1BK_1$  represents the cost of adjusted capital, and the triangle  $i_1AB$  is the residual return to the fixed factor, land. This residual is the land rent per time period. The present value of the annual amounts of  $i_1AB$  is the maximum market price the parcel of land would command if it were undeveloped. Upon

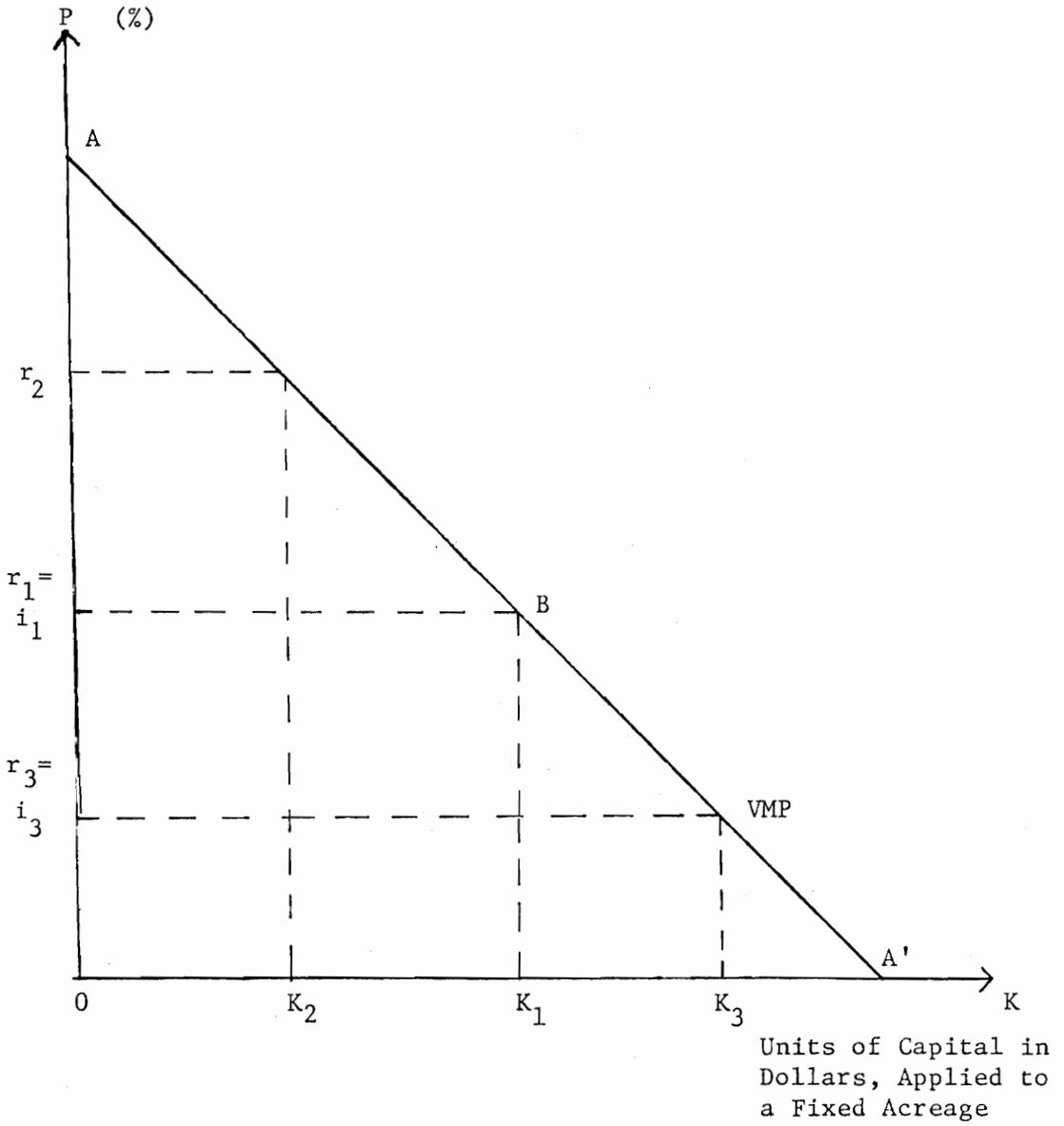


Figure 4. Optimal Level of Investment and Land Rent.

development, the present value of annual amounts of  $OABK_1$  is market price.

Therefore land rent, and hence sale price, is dependent upon forces in the capital market which determine interest rates and upon forces in the product markets which affect prices of the final product thereby shifting the VMP curve. Technological change which alters the marginal productivity of capital will shift the production function and thus the VMP curve.

#### Residential Sites and Land Rent

The theory of land rent as discussed in the preceding section implies that the market price of land depends upon the expected flow of net revenues from the land, since land buyers consider financial gain as their motive for buying land.

In choosing a residential site, the profit motive is not the only factor affecting the potential homeowner's selection of a particular site. Such factors as neighborhood amenities and certain physical characteristics of the property all contribute to the residential site purchaser's attained level of utility. When the land-purchase decision is motivated by profit, it is a production decision with the determinants of profit easily converted to monetary costs and returns and reflected in the VMP schedule discussed above. However, the cost and return framework may have a different interpretation in the case of residential location choice, with the demand schedule for residential land development being perceived as a marginal product schedule.

Lancaster's "new approach to consumer theory" suggests a way to demonstrate correspondence between the two concepts.<sup>2</sup> In Lancaster's framework, goods are not the direct objects of utility. Instead, it is the attributes or characteristics associated with goods which are the objects of utility. Characteristics may be objectively assigned to goods and then subjectively ranked by the individual consumers. As in traditional consumer theory, the consumer attempts to maximize utility given his unique preference ordering over all vectors of characteristics, and given costs and his income. In this sense, the demand for goods is derived from the demand for their characteristics. The implications for residential site selection is that the demand for a particular housing site is a function of the set of utility-creating characteristics of the site. Consumption is a production process in which goods are entered as inputs and costs, and out of which characteristics emerge as outputs and returns. One of these characteristics may be waterfront residential situation.

To capture the site characteristics, a residence and perhaps certain other improvements must be available at the site. The cost of the improvements represents a type of capital outlay necessary to capture the site characteristics. The difference between the "return" on capital improvements and total purchase price of a residential site

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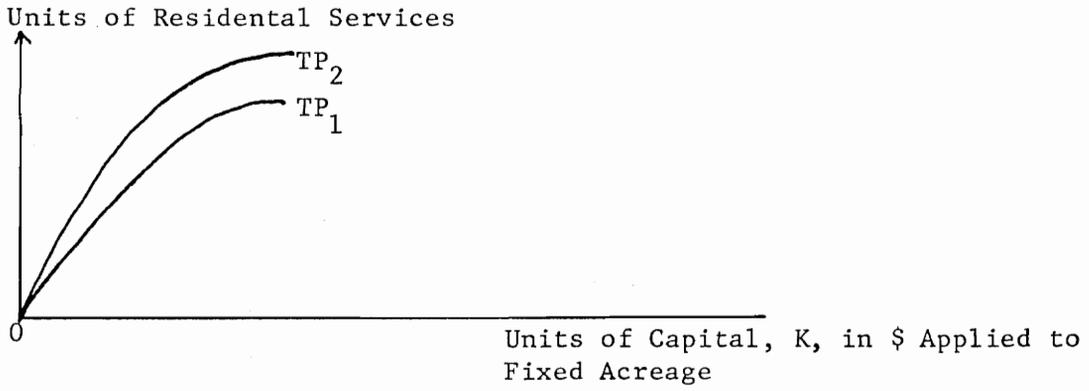
<sup>2</sup>Kelvin J. Lancaster, "A New Approach to Consumer Theory," Journal of Political Economy, LXXIV (April 1966), and Demetrios Damianos and Leonard A. Shabman, Land Prices in Flood Hazard Areas: Applying Methods of Land Value Analysis, Bulletin 95 (Blacksburg, Virginia: Virginia Water Resources Research Center, April 1976), p. 15.

will represent the "rent" earned by the bundle of characteristics of the land itself.

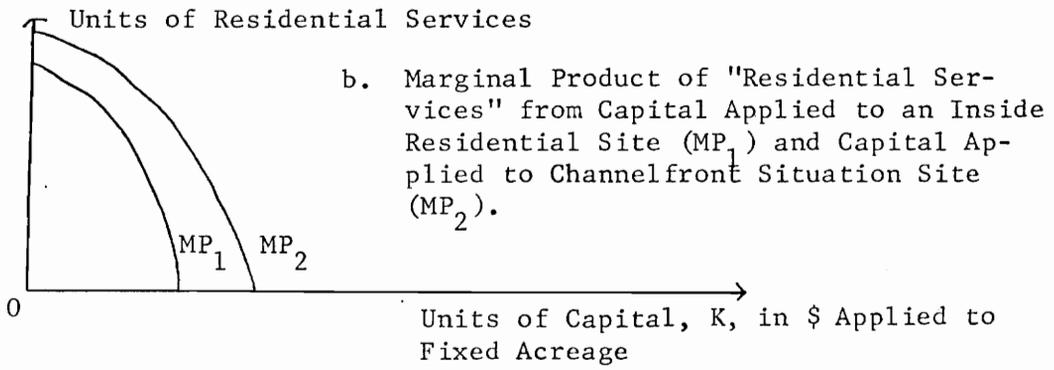
The concepts are analogous to those related in Figure 3. The application of capital to land as a residential site produces "residential services" as its total product. Diminishing, although positive, marginal product of residential services is an intuitively acceptable concept and would be subject to empirical measurement if residential utility could be observed and directly measured. Finally, a VMP curve for residential services would relate per dollar rates of return to alternative levels of capital improvements. Given this concept of the production of residential services, the utility-based rents to various residential sites can be compared. In particular, rent differentials attributable to amenities associated with waterfront situations may be hypothesized.

#### Site Amenities and Rent Differentials

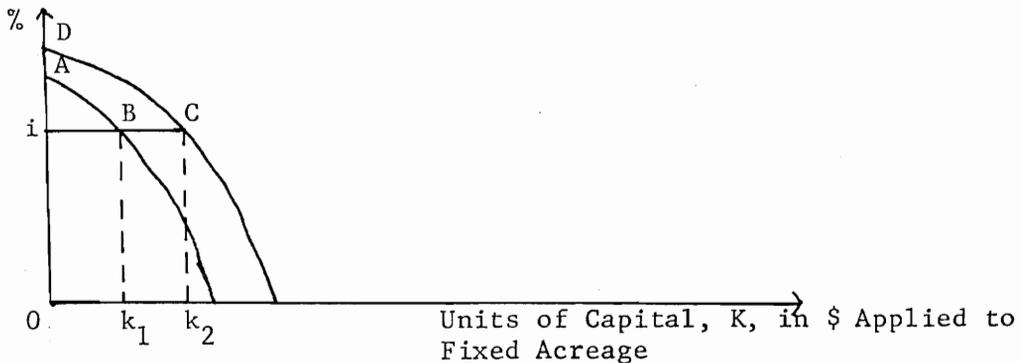
Consider the application of capital as improvements to capture site characteristics of a residential plot of given size. The plot itself is characterized by its surface characteristics, proximity to schools, stores, place of employment, climate conditions and other factors. In a manner quite analogous to that illustrated in Figure 3, application of capital to the land parcel produces a utility-based residential service with total product, marginal product and VMP curves, shown as  $TP_1$ ,  $MP_1$ , and  $VMP_1$ , in Figure 5, a, b, and c, respectively. Although it cannot be measured directly, the residential



a. Total Product of "Residential Services" from Capital Applied to an Inside Residential Site (TP<sub>1</sub>) and Capital Applied to Channelfront Residential Site, (TP<sub>2</sub>), ceteris paribus.



b. Marginal Product of "Residential Services" from Capital Applied to an Inside Residential Site (MP<sub>1</sub>) and Capital Applied to Channelfront Situation Site (MP<sub>2</sub>).



c. Value of Marginal Residential Product from Capital Applied to an Inside Residential Site (VMP<sub>1</sub>) and Capital Applied to a Channelfront Residential Site (VMP<sub>2</sub>), ceteris paribus.

Figure 5. Effects of Channelfront Situation on Returns to Capital Applied to Residential Sites Per Time Period, all Other Inputs Held Constant.

site-owner's decision to invest amount  $OK_1$  in site improvements (Figure 5, c) implies that the VMP in per dollar rates associated with that level of investment just equals the market rate of interest. The present value of the dollar amount represented by  $OABK_1$  per time period for the expected life of the residence will be the market value of the site plus improvements. The present value of amount  $O_iBK_1$  per time period over the expected life of the residence is the return to the investment in improvements. Amount  $iAB$  is the rent attributable to the site with its complement of characteristics.

Consider a residential site comparable in all respects to the one just examined, with the exception that it is located on a channel dredged through a marsh, granting boat access to open water from the residential site. A prospective residential site purchaser recognizes this added characteristic of the site as an extra amenity. Conceptually, the waterfront location acts as a shifter of the TP curve (assuming both site purchasers have identical tastes) from  $TP_1$  to  $TP_2$ . For every dollar spent on capital improvements, a greater total level of site amenities is captured on the channelfront lot than on the inside lot. The difference between  $TP_1$  and  $TP_2$  attributable to the waterfront situation of the second parcel is strictly analogous to the difference in production functions between fertile acreages and less fertile acreages in agricultural production.

The difference between  $TP_1$  and  $TP_2$  is reflected as a shift from  $MP_1$  to  $MP_2$  in Figure 5, b, and, thus a shift from  $VMP_1$  to  $VMP_2$  in Figure 5, c. For a given market rate of interest  $i$ , the upward shift in

the VMP suggests a higher level of capital investment in improvements for capturing site amenities, from  $OK_1$  to  $OK_2$ . For a given level of investment in improvements, the utility-based per-dollar rate of return will be higher for the channelfront site. (Additional investment in improvements may consist of boat docks and bulkheads needed to capture the channelfront amenity in addition to investment needed to capture other site amenities common to both sites).

The shift to the right in VMP curves between the inside residential site and the waterfront site (all other characteristics being identical) results in a greater expected market price for the site-plus-improvements. Of this increase in market price, the present value of amount  $K_1BCK_2$  per time period (over the life of the improvements) is attributable to increased investments in improvements. The present value of amount  $AD CB$  per time period represents rents imputed to the amenities associated with channelfront situation, since the site characteristics are otherwise identical.

To summarize, the market price of a channelfront residential site plus improvements is expected to be:

$$P_c = \sum_{t=1}^T \frac{ODCK_2}{(1+i)^t}$$

where:

$P_c$  = market price of channelfront residence,

$ODCK_2$  = annual returns to site plus improvements,

$i_1$  = the market rate of interest (as well as the rate of return to capital applied to channelfront site at level  $K_2$ )

T = expected life of the residence, and

t = year.

Similarly, the expected market price of a residential site identical in every respect to the channelfront site except for channelfront situation, plus improvements, will be:

$$P_I = \sum_{t=1}^T \frac{OABK_1}{(1+i)^t}$$

where:

$P_I$  = market price of an inside residence (as opposed to channelfront residence),

$OABK_1$  = annual returns to the site plus improvements,

$i_1$  = market rate of interest (as well as the rate of return to capital applied to an inside site at level  $k_1$ ),

$K_1$  = level of investment in improvements, in dollars,

T = expected life of the residence, and

t = year.

The difference in expected market price between the two residences is therefore equal to:

$$P = \sum_{t=1}^T \frac{ODCK_2 - OABK_1}{(1+i)^t}$$

In order to identify the difference in site rents attributable to the channelfront location, it is necessary to first subtract returns turns to capital from total returns in each situation. Difference in market value attributable to channelfront situation is given by:

$$ADCB = \sum_{t=1}^T \frac{(ODCK_2 - OiCK_2) - (OABK_1 - OiBK_1)}{(1 + i)^t}$$

This computation leaves the present value of ADCB per time period as the market valuation of the amenity associated with channel-front location.

Rent Differentials and Demand for Waterfront Sites: Change Over Time

The preceding section demonstrated the conceptual relationship between channelfront situation and residential site rents, representing the effect of channelfront amenities as a shift in the function relating total "production" of residential services to the application of capital improvements ( $TP_1$  to  $TP_2$  in Figure 5, a). For a given, implicit, market determined dollar valuation per unit of residential services, the effect of channelfront situation was a shift to the right in the VMP curve for capital improvements applied to capture the site amenities, as compared to the VMP curve for an otherwise identical inside site.

The implication of Lancaster's theory for residential land prices is that the demand for the services of residential housing location is a function of a set of characteristics which create net utility, of which the amenities of channelfront situation is one. It is conceivable that the demand for a particular amenity or site characteristic could change over time, independently or in addition to changes in demand for residential services in general.

Conceptually, a change in demand for residential services implies a change in the implicit dollar valuation per unit of

residential services, given constant supply conditions. Therefore, an increase in the general demand for residential services would result in a shift to the right of the VMP curve shown in Figure 3, c, all other factors being equal.

If, in addition to a general increase in demand for residential services, there is an increase over time in the demand for channel-front amenities, the result would be an even greater shift to the right in the VMP curve for channelfront properties than for inside properties. This effect over time would cause an increase in the site rent differential between channelfront and inside residential sites.

The time rate of change in values represented by the area ABCD (Figure 5, c) would be a measure of the time rate of change in benefits per unit of wetlands imputed to development uses of wetlands. This time rate of change in benefits per acre of wetlands would be computed as the value,  $\alpha_d$ , which satisfies the following equation:

$$ABCD_t = (1 + \alpha_d)^t (ABCD_{t_0})$$

which resembles:  $b_t = (1 + \alpha_d)^t b_0$

where:

$\alpha_d$  = time rate of change in annual rent per acre of developed wetlands,

$ABCD_t$  = annual rent per acre imputed to channelfront situation, current period,  $t_1$ , and

$ABCD_{t_0}$  = rent per acre imputed to channelfront situation, initial year  $t_0$ .

Given values for  $ABCD_t$ ,  $ABCD_{t_0}$ , and  $t$ ,  $\alpha$  may be found under a financial table for compound interest.<sup>3</sup>

The value of ABCD for a given time period may be derived from the market price differential between channelfront and inside residential sites for that time period, all other things being equal. Recall that market price of residential property is the discounted value of the flow of expected annually recurring rents. The differential between channelfront and inside residential market prices is also a discounted present value, as was demonstrated in the preceding section.

To compute ABCD for a given year, given the market price differential for that year, the values for  $i$  (market rate of interest) and  $T$  (expected useful life of the property) must be known. It must also be assumed that buyers and sellers of residential properties expect the annual return to the channelfront amenity in year  $t + n$  ( $n \leq T$ ) to be equal to the return in year  $t$ . That is, residential land buyers and sellers expect the annual value ABCD to be a constant over time when they compute the expected present value of the channelfront amenity.

That portion of the market price of a residential site attributable to channelfront location may be represented as:

$$P_c = \sum_{t=1}^T \frac{ABCD_{t_0}}{(1 + i)^t}$$

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<sup>3</sup>See: Standard Mathematical Tables, (20th Edition, Cleveland: The Chemical Rubber Co., 1972), pp. 635-642.

where:

$P_{c_{t_0}}$  = portion of market price attributable to  
channelfront amenities in time  $t_0$ ,

$T$  = expected life of the residence,

$ABCD_{t_0}$  = value of the waterfront amenity in the  
year  $t_0$ , and

$i$  = market rate of interest in current year.

The above expression may be solved for  $ABCD_{t_0}$ , given  $P_{c_{t_0}}$ ,  $T$ ,  
and  $i$ , giving:<sup>4</sup>

$$ABCD_{t_0} = \frac{i}{1 - (1 + i)^{-T}} P_{c_{t_0}}$$

Similarly, the value of  $ABCD$  in time period  $t$  may be computed  
if  $P_c$  in time period  $t$  is known, given the appropriate value for  $i$   
in time period  $t$ .

Having, in this manner, computed  $ABCD_{t_0}$  and  $ABCD_t$ , it is pos-  
sible to compute  $\alpha_d$ , using the financial tables for compound interest.

#### Empirical Measurement of Rent Differentials

Empirical analysis to measure effects of certain characteris-  
tics of land on sale price can be accomplished through the use of re-  
gression analysis. Generally, a sample of land market transactions  
is drawn and the importance of factors influencing sale price of the  
land parcels is determined through use of a general estimation model  
of the following form:

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<sup>4</sup>By using a financial table for "Annuity Whose Present Value Is  
1," the factor by which to multiply a present value in order to dis-  
cover the annually recurring value can be found. See: Ibid., pp.  
651-658.

$$P = b_0 + b_1 X_1 + \dots + b_n X_n$$

where  $P$  is the land sale price, and  $X_1, \dots, X_n$  are selected explanatory variables of sale price, such as size of parcel, value of improvements, susceptibility to flooding, or other relevant variables. The regression coefficients,  $b_0, \dots, b_n$ , are direct measures of the importance of each variable in explaining land sale price.

A variation of the simple regression technique is the land sale comparison method which examines the difference in sale prices of land parcels that are comparable along all dimensions except the characteristic for which a measure of market price effects is wanted.

For example, in a study of agricultural land values in relation to the effects of flood hazard, a land value comparison method was employed which examined the difference in sale price of land parcels that are comparable along all dimensions except level of flood hazard. The differences in prices were then attributed to the existence of flood hazard.<sup>5</sup> After theoretically determined explanatory variables were identified, a multiple regression was used to estimate the influence of the variables on flood-free land sale prices. Thus, the coefficients for the resulting regression equations were considered free of any discounting for flood hazard since the flood hazard was non-existent for the selected land sale. Then, using the

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<sup>5</sup> Robert F. Boxley, The Relationship Between Land Values and Flood Risk in the Wabash River Basin, Institute for Water Resources Report 69-4 (Washington, D.C.: Economic Research Service, United States Department of Agriculture, 1969), p. 99.

regression coefficients derived from the analysis of flood-free land sales, and mean values of the explanatory variables for parcels subject to flood hazard, an average sale price for flood-hazard land was predicted. The assertion was that in the absence of flood hazard, the average sale price of land subject to flood hazard would be influenced by the explanatory variables in the same way as the flood-free parcels. By subtracting the actual flood-hazard average price from the predicted average price, the difference attributable to flood hazard was determined. Applications of the land comparison technique isolated the effects of both flood damages and structural protection works on agricultural land values.

In a similar study, the land value comparison technique, described above in reference to agricultural land, was applied to residential sites. An economic theory of land rents was developed which suggested that flood damages, and policies to deal with flood damages, affect the present value of expected annual rents of purchasers of flood-prone lands. Therefore, the sale price of land will be expected to reflect the level of flood hazard.<sup>6</sup> Results of the land comparison technique were generally consistent with the hypothesis that land sale price is negatively related to the potential of flood damage, and that erection of structural flood control measures enhances land prices.

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<sup>6</sup>Demetrios Damianos and Leonard A. Shabman, Land Prices in Flood Hazard Areas: Applying Methods of Land Value Analysis, Bulletin 95 (Blacksburg, Virginia: Water Resources Research Center, Virginia Polytechnic Institute and State University, 1976).

The significance of findings in the studies mentioned is that land market prices do reflect differences in characteristics of land parcels, and the land value comparison technique successfully identified these differences on residential as well as on agricultural tracts of land. The conclusion to be drawn, then, is that statistical analysis of land market sales values may identify imputed values of channelfront amenities reflected in residential land prices and provide an indication of the time rate of change in these values.

#### Procedures

Discussion in the preceding section suggests that amenities of channelfront situation will affect the present value of implicit expected annual rents of purchasers of channelfront residential sites. Therefore, the sale price of land will reflect the market valuation of channelfront amenities.

Based upon that discussion, the following hypotheses concerning development values were developed:

1. The average sale price of residential sites on channels dredged through marshes is greater than the average sale price of non-waterfront residential sites, all other factors being equal.
2. The annual rent attributable to channelfront situation has increased over time.

To test these hypotheses, the land comparison technique will be used. This approach examines the difference in sale price of lands that are comparable along all dimensions except channelfront

situation. By asserting that, in the absence of amenities or disamenities associated with channelfront situation, the influence of identified determinants of the sale price of both channelfront and inside lots would be the same, a technique for dealing with noncomparability of land parcels is derived. A multiple regression model is applied to inside lot sales values and relevant explanatory variables. A mean sale price for channelfront land is then predicted using the regression coefficients derived from the analysis of inside lots. By subtracting the predicted channelfront average price from the actual average price, the difference attributable to channelfront amenities is estimated.

An example of the land comparison method is shown in Table 1. Lines 1 and 2 show the average sale price of channelfront and inside lots. In line 3, the unadjusted difference of -\$2,000 shows the result of the combined effects of all factors which influence sale price, such as lot size and value of improvements, in addition to situation with respect to a channel. Line 4 shows the predicted or estimated price of channelfront lots based upon regression analysis of inside lots. With a predicted price of \$1,500 and an observed price of \$4,000, the difference in price attributable to the amenities of channelfront situation is shown on line 5.

To determine whether this price differential has increased over time, observations on sale price of channelfront and inside properties will be made over a twenty-year period. Results of land value comparison based upon channelfront land prices in early time periods may then be compared with results in later time periods for evidence

Table 1. An Example of the Derivation of the Price Difference  
Attributable to Channelfront Situation Using Land Value  
Comparison.

Item	Amount (dollars)
1. Average Price of Channelfront Parcels	\$4,000
2. Average Price of Inside Parcels	6,000
3. Unadjusted Difference	-2,000
4. Predicted Price of Channelfront Lots	1,500
5. Difference Due to Channelfront Situation	2,500

of change in the market valuation of waterfront residential amenities over time.

The land comparison technique was first applied to the problem of measuring market valuation of flood hazards by comparing flood-plain with non-flood-plain land prices. Some studies have used a 0-1 dummy variable in multiple regression analysis to identify an average differential between flood-plain and non-flood-plain locations of property.<sup>7</sup> This is accomplished by assigning a value of 0 to all observations on flood plains and a value of 1 on all observations on non-flood-plain properties.

As a supplement to the land comparison approach, this study will also employ a 0-1 dummy variable in an attempt to identify an average market price differential for the time period and sample area under observation.

#### Selection of Explanatory Variables

In earlier sections, a theoretical framework was developed for explaining market price differentials among residential parcels, based upon the notion of rent differentials according to differences in site characteristics. Site characteristics can be classified into

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<sup>7</sup>Edward Greenburg, Charles L. Leven, and Alan Schlottman, Analysis of Theories and Methods for Estimating Benefits of Protecting Urban Flood Plains, (St. Louis, Missouri: Institute for Urban and Regional Studies, Washington University, 1974).

five major headings: 1) accessibility, 2) topography, 3) historical factors, 4) improvements, and 5) site amenities.<sup>8</sup>

Residential lots selected for analysis in this study were selected in such a manner that accessibility to such things as commercial centers, parks and highways was approximately the same for all lots. Similarly, lots were selected which are essentially uniform in topography. Therefore, these characteristics were not included in the regression analysis.

Historical factors include changes in the general price level, tax levels and market demand and supply influences. The effects of inflation and general economic conditions on residential land prices are assumed to be well represented by the consumer price index for housing. Since observations on market land prices are in time series as well as in cross section, a variable was included which took the value of the consumer price index for housing associated with the year in which each observation was made.

Improvements on lots are an important source of variation in sales price among lots. The real estate appraiser's value of improvements on the land parcel was used as a general measure of such differences. Site amenities are qualitative factors that cannot be easily quantified. Lot size, income, average age of structures and racial composition can affect the sale price of a land parcel. For this

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<sup>8</sup>See, for example, William J. Stull, "Community Environment, Zoning, and the Market Value of Single-Family Homes," Journal of Law and Economics, XVIII, No. 2 (1975), pp. 535-558.

study, observations from four separate subdivisions were included in the data base. Average lot size differed between subdivisions, but did not differ appreciably within subdivisions. One model was estimated which employed lot size as an explanatory variable. Since it appeared that the lot size variable was serving as a proxy for general amenity differences between subdivisions, the lot size variables was replaced by a set of 0-1 dummy variables to allow for differences in over-all price levels among subdivisions. By design, the one site amenity for which lots were not homogeneous was channelfront situation. This site characteristic was the object of analysis in land value comparisons.

Although a number of characteristics which affect sale price have been identified, not all of them will appear in the regression equations used in this study. Sale price will be expressed as a function of the appraised value of improvements, the consumer price index number for housing, and size of lot. Another equation will be estimated in which lot size as a variable will be replaced with a 0-1 dummy variable to capture general price level differences among subdivisions. All other characteristics that may influence sale price, besides channelfront situation, are controlled for through sampling from homogeneous case study areas.

#### Selection of Area of Investigation

The case study areas selected for investigation were four subdivisions in Virginia Beach. The Virginia Beach area was selected from among other localities containing salt marsh acreage because the

residential demand for waterfront lots has been greater there than in any other locality in Virginia. Residential development during the past two decades has grown at a rapid rate in the areas surrounding Broad Bay, Linkhorn Bay, and Lynnhaven Bay, all of which communicate with the Chesapeake Bay.

The four subdivisions from which observations were drawn were Lynnhaven Colony at the entrance to Broad Bay, Birdneck Point on Linkhorn Bay, Bay Cliff on Mill Dam Creek (off Broad Bay), and the Pine Tree Branch area off the Eastern Branch of the Elizabeth River. Each subdivision surrounds inlets or coves with some lots situated on dredged channels, and with similar, "inside," lots nearby. Observations were drawn from four subdivisions to guard against the possibility of selecting any one subdivision completely atypical of water and channelfront development in Virginia Beach.

Data on land sale prices, appraised value of improvements, size of the lot, location of the lot with respect to subdivision, situation of the lot with respect to channelfront or inside designation, and date of sale were gathered using real estate appraisal and taxation records, along with subdivision plat maps made available by the Office of Real Estate Appraisers for the City of Virginia Beach. A total of 292 observations were obtained from four subdivisions for the period 1955-1975. Of this total, 124 observations were on inside lots.

### Empirical Analysis

This section reports the findings of the empirical analysis. The first two equations were designed to test the hypothesis that channelfront lots sold for a higher average price, taken over all twenty years and all four subdivisions, than did inside lots. This was achieved by use of a dummy variable assigned a value of 1 for all channelfront observations and 0 for all inside observations.

The second two equations were estimated for use with the land comparison technique. They are applied first to estimation of the average price differential over all observations, between channelfront and inside lots, and are then applied to the task of identifying changes over time in the channelfront inside price differential.

#### Average Differential, Measured by Dummy Variable

Equation 1 was of the following form with results as indicated:

$$Y = - 21525 + 0.549X_1 + 2825X_2 + 305.9X_3 + \dots \quad (1)$$

$$t = 16.18 \quad t = 2.10 \quad t = 9.71$$

$$\alpha = 0.001 \quad \alpha = 0.05 \quad \alpha = 0.001$$

$$\dots + 5584.7X_4 + 5684.1X_5 + 2923.0X_6$$

$$t = 2.65 \quad t = 2.43 \quad t = 1.47$$

$$\alpha = 0.010 \quad \alpha = 0.015 \quad \alpha = 0.15$$

$$\bar{R}^2 = .74 \text{ (multiple correlation coefficient corrected for degrees of freedom)}$$

$$n = 292 \text{ (number of observations)}$$

$$D.W. = 1.76 \text{ (Durbin Watson statistic)}$$

where:

- Y = nominal sale price of residential parcels,
- $X_1$  = appraised value of improvements at time of sale,
- $X_2$  = dummy variable assigned value of 1 for channel-front observation,
- $X_3$  = consumer price index for housing, 1967 = 100,
- $X_4$  = dummy variable assigned value of 1 for all Pine Tree Branch observations,
- $X_5$  = dummy variable assigned value of 1 for all Bay Cliff observations, and
- $X_6$  = dummy variable assigned value of 1 for all Bird Neck Point observations.

The relatively high  $\bar{R}^2$  indicates that the equation accounts for much of the variation in sale price of residential parcels.

All coefficients are significant at the 5% level except that for the dummy variable representing market price differentials attributable to situation of the parcel in Bird Neck Point. (Dummy variables  $X_4$ ,  $X_5$ , and  $X_6$  were included to identify differences in general real estate price levels among subdivisions.)

The value of 2825 for  $X_2$  is interpreted to mean that, on the average, channelfront lots sold for \$2825 dollars more than did inside lots, over all observations and all time periods. This result lends support to the hypothesis that the real estate market imputs a positive value to the waterfront amenity, frequently created by dredging channels through marshes at the tips of coves in tidal areas of Virginia.

Equation 2 is similar in intent to Equation 1, in that it uses a dummy variable to identify an average differential between channel-front and inside residential site prices. The difference between the

two equations is that the second includes lot size as a variable and eliminates dummy variables for different subdivisions. Results using Equation 2 are as follows:

$$Y = - 19377 + 0.96X_1 + 2003X_2 + 203.9X_3 + 284.7X_4 \quad (2)$$

$$t = 34.94 \quad t = 2.47 \quad t = 12.50 \quad t = 4.52$$

$$\alpha = 0.001 \quad \alpha = 0.015 \quad \alpha = 0.001 \quad \alpha = 0.001$$

$$\bar{R}^2 = .90$$

$$n = 292$$

$$D.W. = 1.93$$

where:

Y = nominal sale price of residential parcels,

X<sub>1</sub> = appraised value of improvements at the time of sale,

X<sub>2</sub> = dummy variable assigned a value of 1 for channel-front observations,

X<sub>3</sub> = consumer price index for housing, 1967 = 100, and

X<sub>4</sub> = lot size in thousands of square feet.

This model specification produces a higher  $\bar{R}^2$  value than does Equation 1. All coefficients are highly significant and of the expected sign.

The coefficient for X<sub>2</sub> suggests that the market price of channelfront lots, on the average, exceeded that for inside lots by the amount of \$2003. Although somewhat less than the value derived using Equation 1, the sign and magnitude of this coefficient also lends support to the hypothesis that real estate markets imputed a value to channelfront amenities.

Average Differential by Land Value Comparison

Equations 3 and 4 were estimated for use with the land value comparison technique. Coefficients for both equations were estimated by subjecting 124 observations on transactions involving inside parcels over the 25-year study period and over four subdivisions. In these equations there is no need for a dummy variable to distinguish inside from channelfront lots. The difference between Equation 3 and Equation 4 is the use of dummy variables to identify differences in price levels among subdivisions in Equation 3. Equation 4 uses lot size as a possible source of differences in sale value, not only within, but between subdivisions.

Equation 3 was of the following form with results as shown:

$$Y = - 11880 + 0.99X_1 + 155.0X_2 + 6467X_3 + 3038X_4 \quad (3)$$

$$t = 26.22 \quad t = 4.49 \quad t = 3.06 \quad t = 1.67$$

$$\alpha = 0.001 \quad \alpha = 0.00 \quad \alpha = 0.01 \quad \alpha = 0.1$$

$$\bar{R}^2 = .92$$

$$n = 124$$

$$D.W. = 2.02$$

where:

Y = nominal sale price of residential parcels,

X<sub>1</sub> = appraised value of improvements at time of sale,

X<sub>2</sub> = consumer price index for housing, 1967 = 100,

X<sub>3</sub> = dummy variable with value of 1 for all Bay Cliff observations, and

$X_4$  = dummy variable with<sup>9</sup> value of 1 for all Bird Neck Point observations.

Again, a high  $\bar{R}^2$  indicates that the equation accounts for much of the variability in sale value among inside (non-channelfront) lots. All coefficients are statistically significant. The coefficients for dummy variables representing Bay Cliff and Bird Neck Point observations suggest that the over all average price of inside residential properties in these subdivisions averaged \$6467 and \$3038 more, respectively, than the average price of inside properties in the Lynnhaven Colony and Pinetree Branch areas. Equation 4 suggests that part of the average differential among subdivisions is attributable to lot size differences, but other factors may account for part of the difference. The use of dummy variables to represent different subdivisions was designed to identify affects of such factors upon price levels before application of the equation to the land comparison technique.

Using Equation 3, the land comparison technique was employed to isolate the land price difference which stemmed from the channelfront inside location difference. For all sales the estimated difference due to channelfront situation was \$2311, or an 11% premium in the land price due to channelfront location (see Table 2). This difference may be compared to the value of \$2825 estimated by Equation 1 using a dummy variable for waterfront situation, and the value of \$2003 estimated by Equation 2.

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<sup>9</sup>A dummy variable representing Pinetree Branch observations was discarded when the coefficient was not significant, and the coefficients were estimated again.

Table 2. Comparison of Average Lot Values for Channelfront and Inside Lots, Using Equation 3.

Item	Amount (dollars)
1. Average Price, 168 Channelfront Lots	\$23,259
2. Average Price, 124 Inside Lots	27,305
3. Unadjusted Difference	-4,046
4. Estimated Price of Channelfront Lots	20,948
5. Difference Due to Channelfront Amenity	2,311

Equation 4 was also estimated for use with land value comparison. It differs from Equation 3 in that it includes lot size as a variable and does not use dummy variables to distinguish observations on different subdivisions. The primary reason for including Equation 4 was to compare performance of an equation using the lot size variable with one using dummy variables, and to check for stability of coefficients for the other variables between the two equations.

Equation 4 was of the following form with results as indicated:

$$Y = - 19206 + 0.97X_1 + 202.6X_2 + 265X_3 \quad (4)$$

$$t = 26.24 \quad t = 8.16 \quad t = 2.69$$

$$\alpha = 0.001 \quad \alpha = 0.001 \quad \alpha = 0.01$$

$$\bar{R}^2 = .92$$

$$n = 124$$

$$D.W. = 2.04$$

where:

Y = nominal sale price of residential parcels,

X<sub>1</sub> = appraised value of improvements in the year of sale,

X<sub>2</sub> = consumer price index for housing, 1967 = 100, and

X<sub>3</sub> = lot size in thousands of square feet.

Again, the  $\bar{R}^2$  value is high and all coefficients are statistically significant.

Application of Equation 4 to the land comparison technique to isolate price differentials due to channelfront amenities gave an average difference over all observations of \$1874 between channelfront prices and inside prices. This is a 9% premium attributable to

channelfront situation (see Table 3). Compare this with \$2311 using Equation 3 and the land comparison technique, and with \$2825 and \$2003 using the dummy variable in Equations 1 and 2.

#### Changes in Market Price Differentials Over Time

This section employed Equation 3 and 4 and the land comparison technique to determine whether or not the sample data contains evidence of a trend, over time, in the value implicitly imputed by real estate markets to channelfront amenities for residential sites. Results using Equation 3 and Equation 4 are presented for purposes of comparison.

The regression coefficients estimated using observations on inside lots are applied to average values for the independent variables observed on sales of channelfront lots for each year, from 1955 to 1975. The value predicted for the average sale price of channelfront lots in each year is subtracted from the observed average sale price of channelfront lots in the corresponding years. The differential computed in this manner is the discounted present value of the channelfront amenity.

In order to convert these discounted present values of channelfront amenities into corresponding recurring annual values, they may be treated as present values of annuities. Given the appropriate discount rate and the life of the annuity, the corresponding amount of the recurring annual net value can be computed using the appropriate financial table.<sup>10</sup> This value for each year can be interpreted

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<sup>10</sup>See financial table for "Annuity Whose Present Value Is 1," in Standard Mathematical Tables, op. cit., pp. 651-658.

Table 3. Comparison of Average Lot Values for Channelfront and Inside Lots, Using Equation 4.

Item	Amount (dollars)
1. Average Price, 168 Channelfront Lots	\$23,259
2. Average Price, 124 Inside Lots	27,305
3. Unadjusted Difference	4,046
4. Estimated Price of Channelfront Lots	21,385
5. Difference Due to Channelfront Amenity	1,874

as the annual value imputed by the real estate market to channelfront amenities.

Mortgage rates on new home mortgages, reported in the Federal Reserve Bulletin, would seem to represent the discount rate relevant for residential properties. It must be remembered, however, that the estimated present values of the channelfront amenity are net of effects of inflation.

For a given discounted present value, the higher the assumed rate at which the flow of annual benefits was discounted, the larger the annualized value will be. Therefore, if the estimated discounted present value is net of the effects of inflation, an assumed discount rate which has an inflation component "built in" will over-estimate annualized values.

If mortgage rates on new home mortgages are used to compute annualized values, the assumption must be that no inflation component is included in the mortgage rate. If an inflation component is included in the mortgage rate, the annualized value will be over-estimated when applied to discounted present values which are net of inflation.

An alternative assumption is that observed increases in mortgage rates over time reflect adjustments to allow for inflation in housing prices. If estimated discounted present values are net of effects of inflation (1967 = 100), then a constant mortgage rate equal to that observed for 1967 is the appropriate rate upon which to compute annualized values for all years.

Estimated market prices for channelfront amenities were annualized subject to each of the above assumptions for purposes of comparison. The first assumption probably causes over-estimation of the average annual rate of increase in the real value of benefits imputed to channelfront residential situation. The second assumption probably yields a conservation estimate.

The average life of the channelfront amenity was assumed to be equivalent to the average term of a residential real estate mortgage, or approximately 25 years.<sup>11</sup>

The land value comparison technique was conducted, first using Equations 3 and then Equation 4. A market price differential (discounted present value) and corresponding annual value were computed for each year. These results are summarized in Tables 4 and 5, for Equations 3 and 4, respectively. Column 1 in each table shows the year, from 1955 through 1975. Column 2 indicates the number of channelfront observations used in computing annual average values. Column 3 contains the differentials computed by the land value comparison technique for each year. Column 4 shows the mortgage rates, over time, used to compute annual values corresponding to the net present value of Column 3, given the assumption that mortgage rates do not reflect an allowance for inflation. Column 5 contains the computed annual values based upon this assumption. Column 6 presents five-year averages of these values. Column 7 contains the computed annual

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<sup>11</sup>Mortgage rates and maturity ages of average residential real estate loans are reported in a table headed "Terms and Yields on New Home Mortgages," in the Federal Reserve Bulletin.

Table 4. Values Imputed by Market to Channelfront Amenities, Using Equation 3 and Land Value Comparison.

Year	Number of Channelfront Sales	Price Difference Due to Channelfront Situation	Mortgage Rate (Percent)	Annual Values $A_{a/}$	Annual Values Five Year Averages	Annual Values $B_{b/}$	Annual Values Five Year Averages
1955	15	1,611	5.50	120	104	132	113
1956	11	730	5.58	55		60	
1957	6	450	5.66	34		37	
1958	12	1,810	5.74	138		148	
1959	13	1,691	5.82	130		139	
1960	5	4,261	5.90	330	122	349	130
1961	4	2,291	5.98	179		188	
1962	10	533	5.93	41		44	
1963	5	1,005	5.84	77		82	
1964	6	1,097	5.78	83		90	
1965	5	2,500	5.74	191	176	205	174
1966	7	526	6.14	42		43	
1967	7	3,074	6.33	248		252	
1968	2	1,807	6.83	153		148	
1969	7	2,581	7.66	235		212	
1970	-	-	8.27	-		-	
1971	7	4,835	7.60	438	313	396	272
1972	13	1,533	7.45	137		126	
1973	11	1,834	7.78	169		150	
1974	4	8,599	8.71	855		705	
1975	3	5,969	8.83	599		489	

a/ Assumes no inflation factor is included in the Mortgage Rates in Column 4.

b/ Assumes inflation factor is included in Mortgage Rates in Column 4: all values annualized on 1967 rate.

Table 5. Values Imputed by Market to Channelfront Amenities, Using Equation 4 and Land Value Comparison.

Year	Number of Channelfront Sales	Price Difference Due to Channelfront Situation	Mortgage Rate (Percent)	Annual Values A <sup>a/</sup>	Annual Values B <sup>b/</sup>	Annual Values: Five Year Averages	Annual Values: Five Year Averages
1955	15	1,985	5.50	148	163	108	117
1956	11	477	5.58	36	39		
1957	6	243	5.66	18	20		
1958	12	2,008	5.74	153	165		
1959	13	1,611	5.82	124	132		
1960	5	3,422	5.90	265	281	124	131
1961	4	1,600	5.98	125	131		
1962	10	1,154	5.93	90	95		
1963	5	1,368	5.84	105	112		
1964	6	1,023	5.78	78	84		
1965	5	2,937	5.74	224	241	115	119
1966	7	254	6.14	20	21		
1967	7	3,063	6.33	247	251		
1968	2	341	6.83	29	28		
1969	7	280	7.66	25	23		
1970	-	-	-	-	-		
1971	7	5,067	7.60	459	415	200	176
1972	13	1,257	7.45	112	103		
1973	11	406	7.78	37	33		
1974	4	4,838	8.71	481	397		
1975	3	2,000	8.83	201	164		

a/ Assumes no inflation factor is included in the Mortgage Rates in Column 4.

b/ Assumes inflation factor is included in Mortgage Rates in Column 4: all values annualized on 1967 rate.

values based upon the assumption that increases in mortgage rates over time reflect allowances for inflation. The mortgage rate for 1967 is used to annualize the estimated differentials for all years, 1955 through 1975. Column 8 presents five-year averages of these values.

Examination of values through time in column 3, column 5, or column 7 of either table shows considerable variability in values imputed to the channelfront amenity. No single, obvious, explanation for this variability is apparent. However, it was considered that the relatively small number of channelfront observations for each year (column 2) makes application of the land comparison technique highly susceptible to the effects of individual observations which diverge from the normal or mean values over a four or five-year period. For this reason, annual values for the channelfront amenity were recomputed on the basis of five-year averages. These values are plotted against time, for Equation 3 in Figures 6 and 7, and for Equation 4 in Figures 8 and 9.

The results represented in Figures 6 and 7 suggest that the market price imputed to the amenities of channelfront situation, on the basis of annual rent per residential site, have increased over time at an increasing rate. The rate of increase represented in Figure 6 is greater than that shown in Figure 7, reflecting the difference in assumption concerning the appropriate rate at which real present values should be annualized.

Figures 8 and 9 show no general increase or decrease in the average annual price imputed to channelfront amenities, except in the

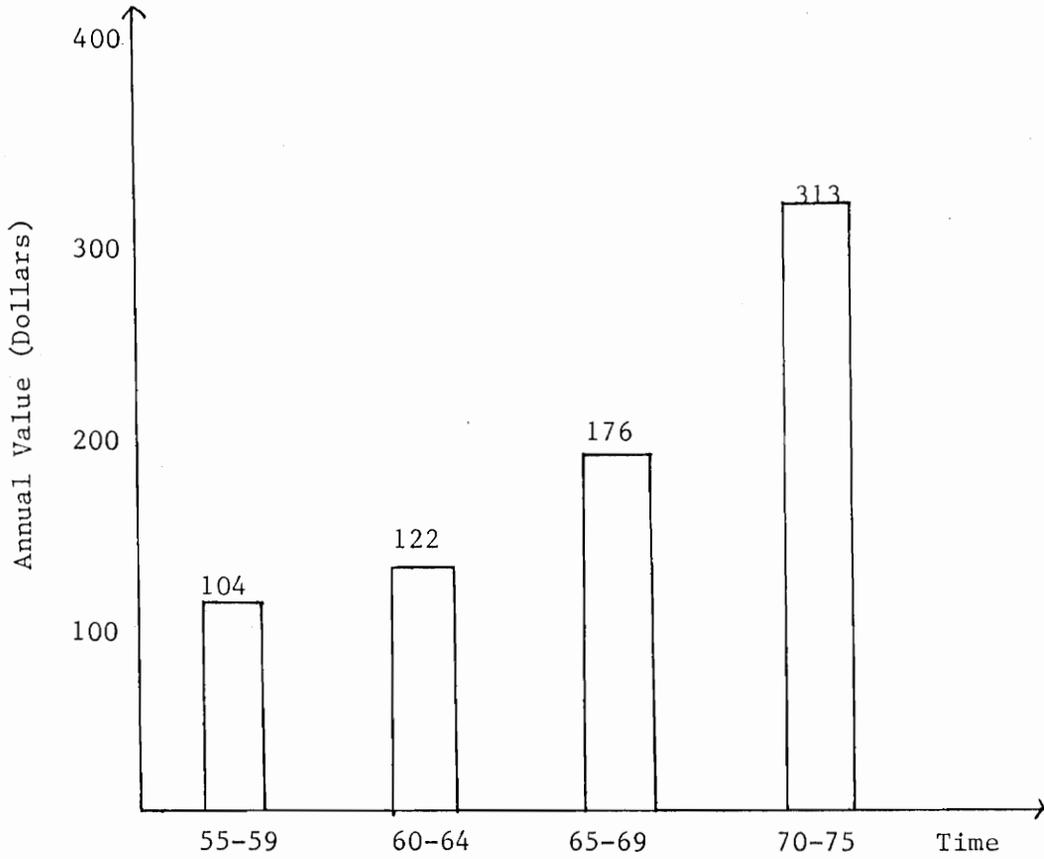


Figure 6. Average Annual Value Per Lot of Channelfront Amenity, Using Equation 3, Assumption A and Land Value Comparison, 1955-1975.

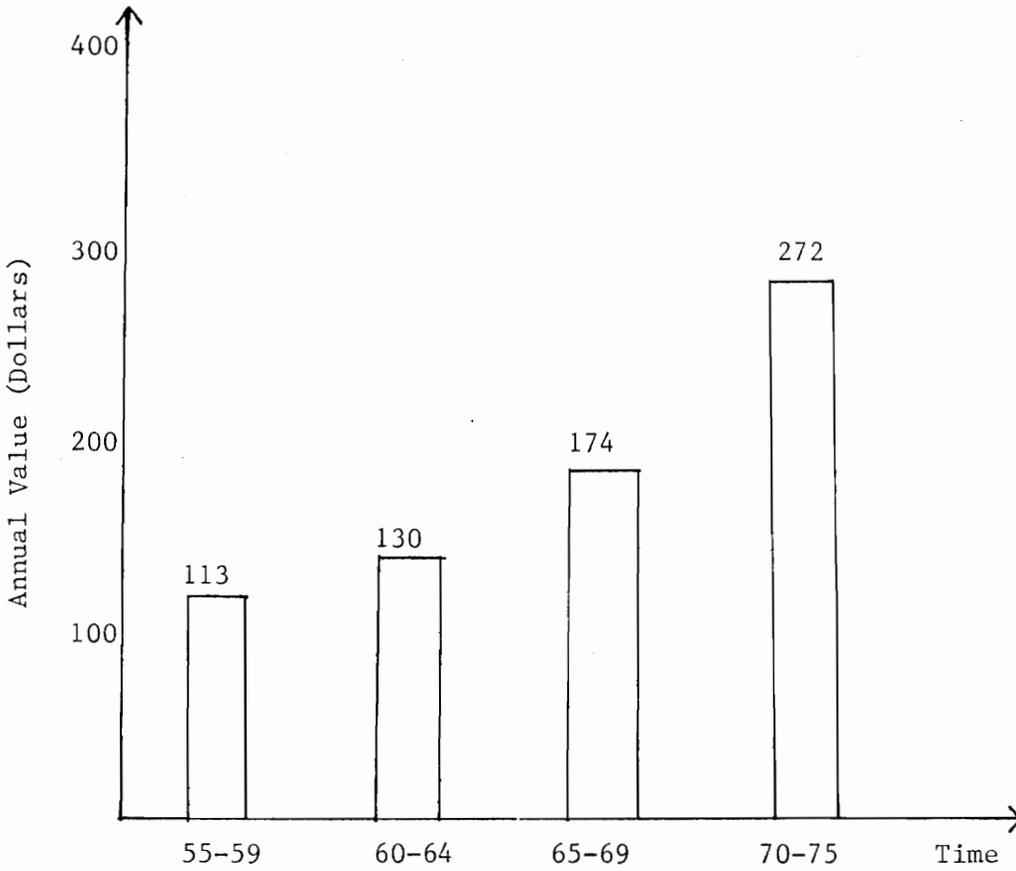


Figure 7. Average Annual Value Per Lot of Channelfront Amenity, Using Equation 3, Assumption B, and Land Value Comparison, 1955-1975.

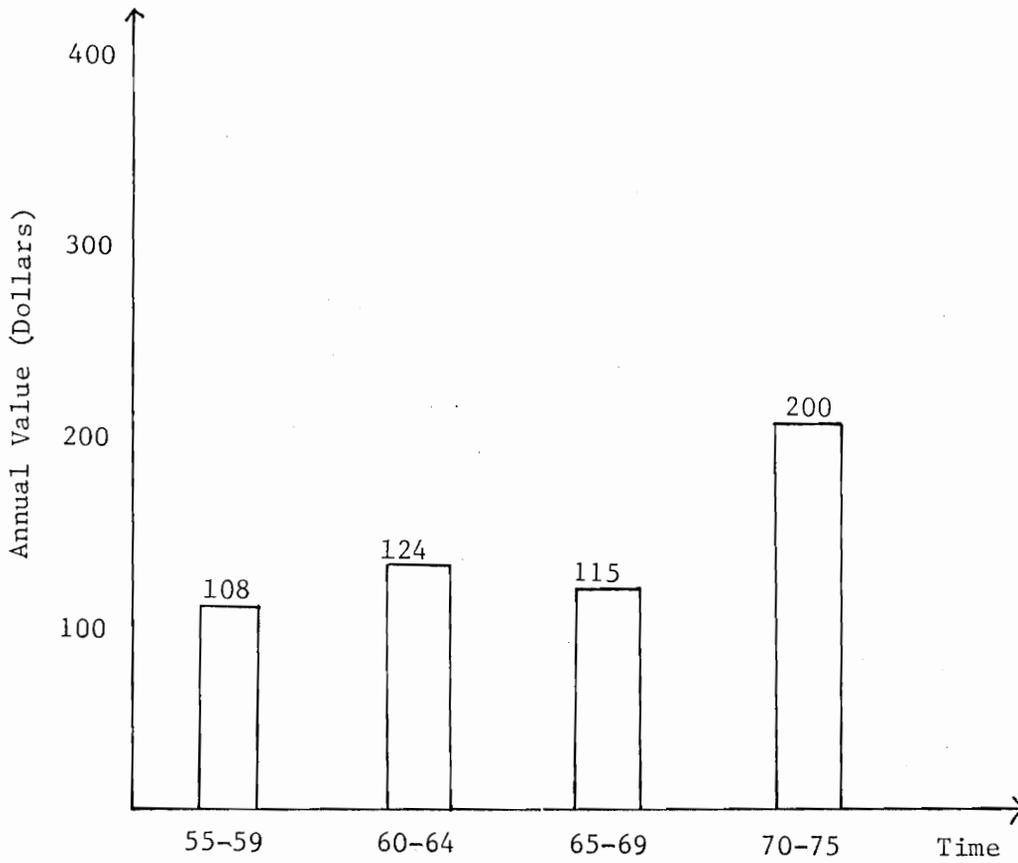


Figure 8. Average Annual Value Per Lot of Channelfront Amenity, Using Equation 4, Assumption A, and Land Value Comparison, 1955-1975.

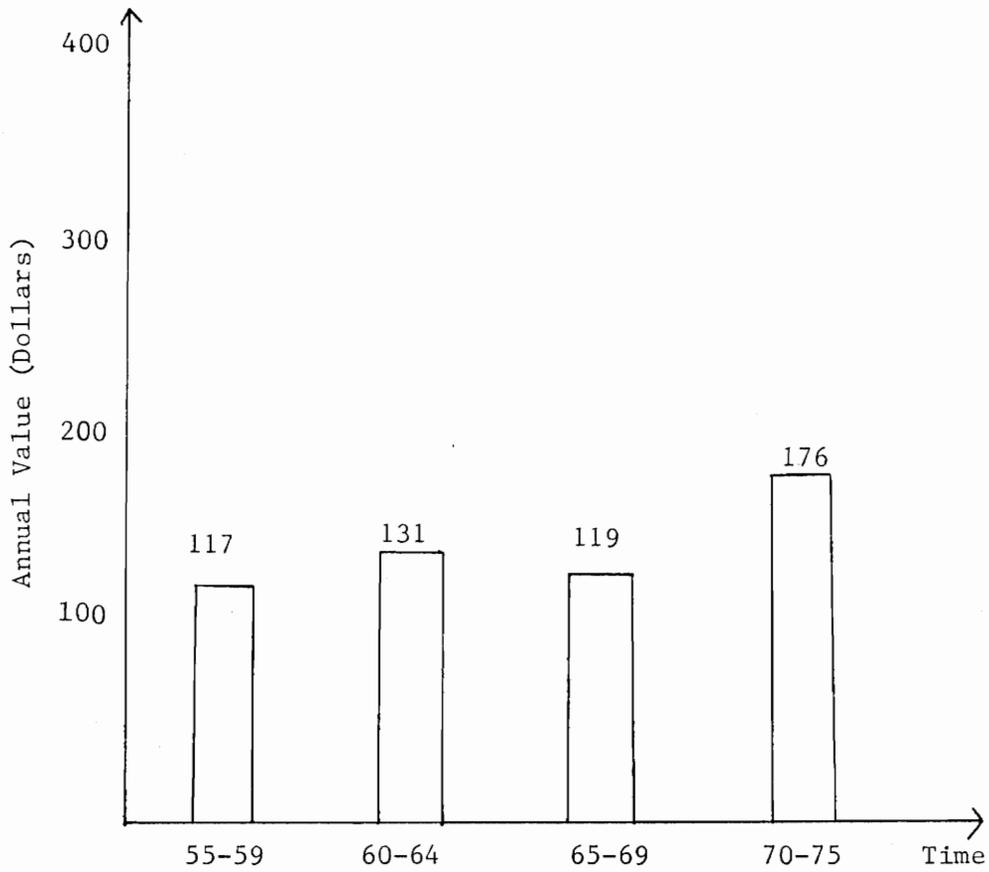


Figure 9. Average Annual Value Per Lot of Channelfront Amenity, Using Equation 4, Assumption B and Land Value Comparison, 1955-1975.

most recent time period where a rather dramatic increase is observed. The results in Figures 8 and 9 differ from those in Figures 6 and 7 because the regression equation used for land value comparison in Figures 8 and 9 used lot size as a variable which isolated differences in real estate price levels among subdivisions. Results in Figures 6 and 7 were derived from a regression equation which employed dummy variables to isolate differences in real estate price levels among subdivisions.

Since there was little variability in lot size within subdivisions, Equation 3 using dummy variables to isolate differences in real estate price levels among subdivisions is probably the better predictive equation of the two.

For this reason, the results presented in Figures 6 and 7 are probably more representative of actual imputed amenity values than are those in Figures 8 and 9.

#### Estimating and Interpreting $\alpha_d$

To compute the time rate of change in the average annual value per lot of channelfront amenity, the results derived from Equation 3, presented in Figures 6 and 7 were used.

Based upon results presented in Figure 6, annual values increased from an average of \$104 per lot per year in the first period to \$313 per lot in the final period, over 21 years, representing a 300 percent increase. Consulting the financial table for compound interest, it is found that a 300 percent increase in value over 21

years corresponds to an average annual rate of increase of 0.055 or 5.5 percent.

Results presented in Figure 7 indicate an increase from an average of \$113 per lot per year in the first period to an average of \$272 per lot per year in the final period, or an increase of 241 percent over 21 years. This represents an average annual increase of 0.0425 or about 4.25 percent per year.

These results can be interpreted as evidence that  $\alpha_d$  is equal to some value between 4.25 percent and 5.5 percent. This interpretation is based upon several assertions:

1. demand for wetlands in development is derived from the demand for open water access from residential sites, created by channeling and filling marshes,
2. a measure of the benefits attributable to wetlands in development is the market-imputed value of residential amenities associated with situation on a channel,
3. the value of channelfront amenities is equal to the difference in average price of channelfront properties and otherwise identical inside or non-channelfront properties, and
4. a measure of the time rate of change in the benefits of wetlands in development is the change over time in the market price differential between channelfront and inside lots.

It must be further noted that the value of 4.25% to 5.5% per year represents the time rate of increase in average annual value of developed wetlands and is also approximately equal to the value of marginal wetlands acreages in development. This value for  $\alpha_d$  does not pertain to all wetlands, since not all wetlands are developed or in demand for development uses.

In contrast, those uses of wetlands from which preservation benefits are derived draw from the ecological productivity of wetlands generally, with specific location or parcel size of wetland acreage being of minor importance at the margin.

These factors must be kept in mind when relating an estimated value for  $\alpha$  in development to estimated values for  $\alpha$  in preservation. One additional observation should be noted. There is evidence that the value for  $\alpha_d$  prior to 1970 was only about 3 percent per year, and that the value imputed to the channelfront amenity increased more rapidly in the later period than in the earlier period. One explanation could be that implementation of the Wetlands Act created the expectation among owners of channelfront sites that future development of such sites would be curtailed. Expectation of future restrictions on the availability of channelfront sites might have resulted in a relatively large increase in the market-imputed value of the channelfront amenity in the latter period.

Under these circumstances, the perceived value of  $\alpha_d$  for wetlands as channelfront residential sites prior to the Act might have been only about 3 percent.

### Summary

This chapter presents a study which seeks to measure changes in the benefits from residential uses of wetlands. The market value of land, and of characteristics of land, is defined within the context of an economic theory of land rent. A land value comparison technique, employing regression analysis, was used to identify changes over time in the market-imputed value of amenities associated with situation of a residence on a channel. Data was acquired from sample subdivisions in Virginia Beach, Virginia, covering a 21-year period. For the Virginia Beach case study, the average annual market-imputed value of channelfront situation per residential site increased from about \$100 in 1955 to about \$300 in 1975. This represents an average annual rate of growth of about 4.25 to 5.5 percent per year. Granting the assertion that the market value of channelfront situation is a legitimate indicator of the value of wetlands in development, then a value of  $\alpha_d$  of between 4.25 and 5.5 percent is inferred from the results of this study. The annual values and the time rate of growth apply only to developed wetlands and not to each acre of undeveloped wetlands. These values may over-estimate those perceived prior to implementation of the Wetlands Act, since the estimated market imputed value of the channelfront amenity increased more rapidly in the final period than in earlier periods.

## CHAPTER IV

### THE PRESERVATION ALTERNATIVE

This chapter identifies sources of demand for the ecological services of wetlands. It seeks to identify variables which could be expected to shift the demand for wetlands. Using empirical data, time changes in variables which shift the demand for wetlands are measured. The implications of these changes for the perceived ecological value of wetlands are explored, using various assumed values for the parameters relating demand shifters to the demand for wetlands.

The first section of this chapter explores the relationship between the demand for recreational sport fishing and the value of ecologically productive wetlands. The second section of this chapter examines implications of using shifts over time in the demand for seafood as a basis for perceived changes in the value of preserved wetlands.

#### Sport Fishing and the Value of Wetlands

The demand for ecological products of Virginia's wetlands is in part a derived demand. An important source of demand for wetlands is the demand for marine species which, in turn, is derived from demand for sport fishing opportunities.

Demand for Wetlands as a Derived Demand

Conceptual linkages between demand for sporting fishing opportunities and the demand for ecologically productive wetlands can be clarified by treating fish for stocking marine fishing waters as though they were produced in the manner of cattle or hogs. In the discussion which follows, it is assumed that full appropriability and excludability obtain in the production and provision of fish with which to stock marine fishing waters, specification of production functions for marine species and full appropriation and excludability apply with respect to inputs to that production function.

Sport fishing in the Chesapeake Bay and adjoining bodies of water is a recreational experience from which participants derive utility. Part of the utility is derived from aesthetic appreciation of a boat ride in open waters. For a sport fisherman, an important component of the experience is catching and landing fish using a particular technique with a particular tackle.

Sport fishing requires that waters be stocked with fish. If production and marketing of fish for stocking fishing waters were subject to full exclusion and appropriation, sport fishermen would be compelled to pay for having the water stocked. A fisherman's utility from sport fishing is in part a function of his success at catching fish. If there are too few fish in the water, his utility is reduced. If there are too many fish in the water, the sporting aspect of fishing is lost as it becomes too easy to land a fish. We assume that some range of fish population levels yield positive

utility for fishermen so that downward sloping individual and aggregate demand curves for fish-stock exist.

If fish for stocking marine fishing waters were produced in the manner of cattle or hogs, we could posit an upward-sloping supply curve for game fish populations.

An intersection between aggregate supply and demand curves for game fish populations would indicate the equilibrium game-fish population level, and the price paid per unit of population, all other factors being equal. (See Figure 10.)

Figure 1 shows a hypothetical equilibrium at price  $P_0$  say, per 1000 fish, at quantity  $Q_0$ , between sport fishermen's aggregate demand curve and the aggregate supply curve of producers of fish stocks.

Detritis, formed by decaying marsh vegetation is known to be an essential part of the food-web sustaining marine life. Marsh vegetation also harbors juvenile species until they are viable. Marshes, then, are inputs in a hypothetical production function for sport-fish stocks.

Assuming declining marginal productivity of marsh acres per unit of game-fish stocks, we may construct the marginal value product curve (MVP) for marshes. This curve would represent the demand curve for marshes as a productive input. (See Figure 11.)

Under competitive conditions, fixed supplies of marsh acreages would be allocated among alternative uses in such a manner that marginal value products of marsh acreages would be equal among uses.

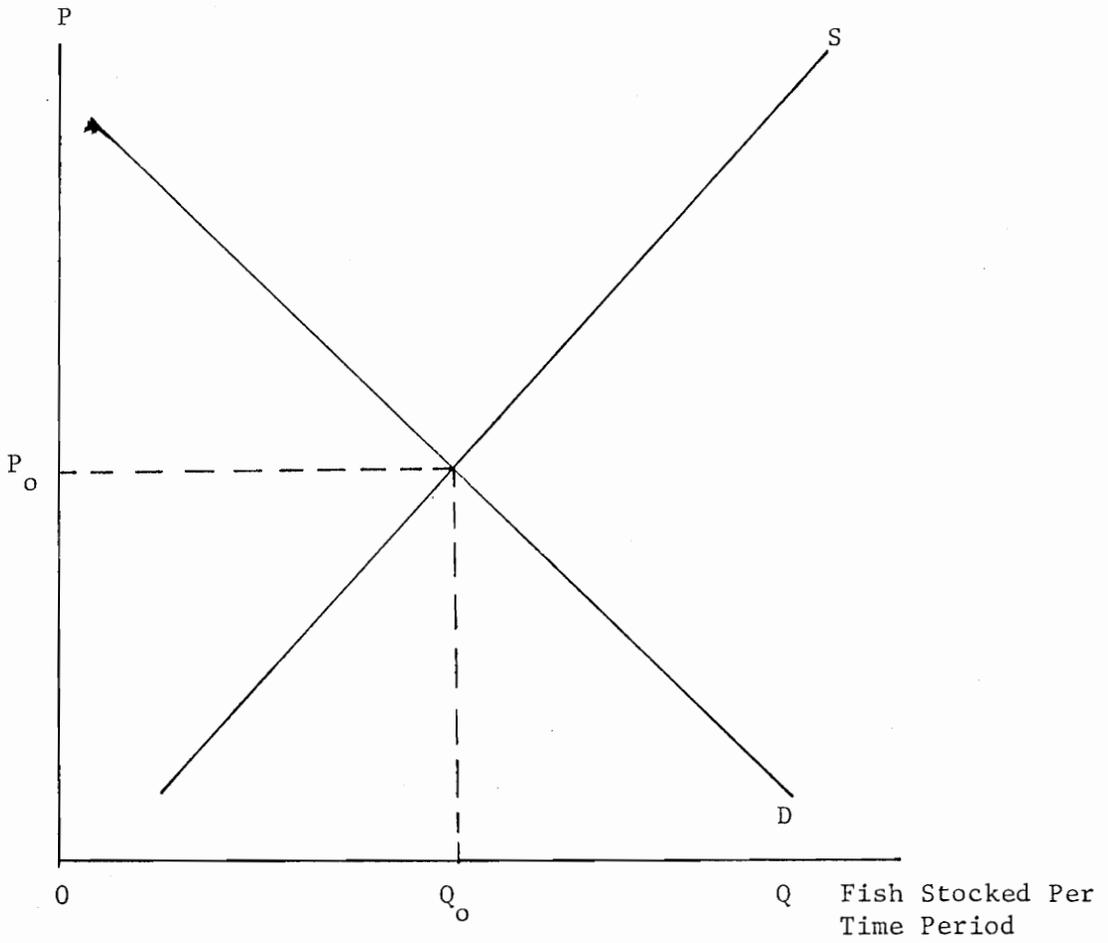


Figure 10. Market Equilibrium in a Hypothetical Fish-Stocking Industry.

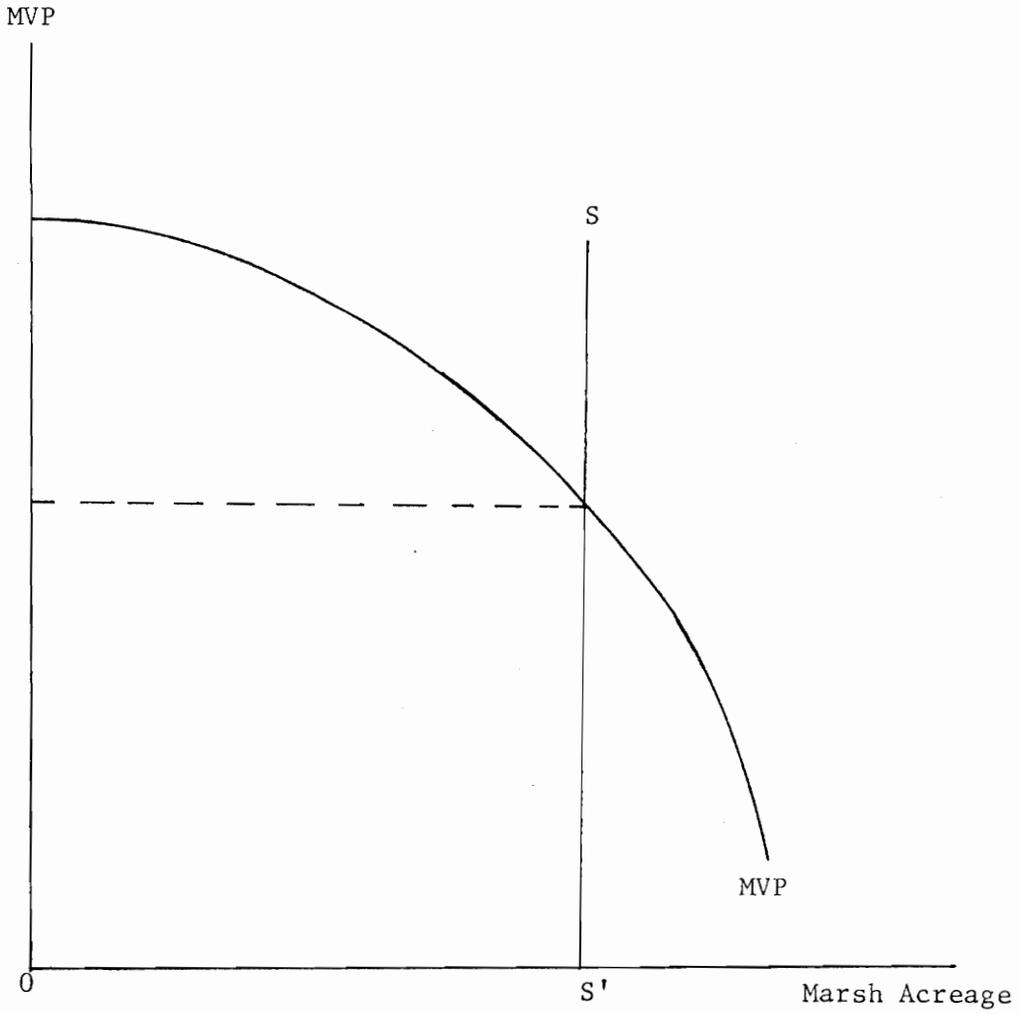


Figure 11. Hypothetical MVP Curve for Marsh Acreages.

The purpose of the foregoing exercise is to illustrate, conceptually, the manner in which demand for ecological products of wetlands is derived from the demand for sport fishing experiences.

#### Shifts in the Derived Demand for Wetlands

In the preceding section the demand curve for ecologically productive wetlands was represented by its marginal value product curve as an input in an assumed marine species production function. In this sense, the demand for ecologically productive wetlands is derived from the demand for stocks of marine species. One important source of demand for marine species is that attributable to sport fishermen.

A shift in the sport fishing demand for marine species, given a supply function which is less than completely elastic, will cause an increase in the price (again assuming marketability) for stocks of marine species. This increase in price will shift to the right the MVP curve for ecologically productive wetlands.

To conceptualize changes in the demand for wetlands, we must understand changes in sport fishermen's demand for marine species. Economic theory tells us that a decrease in the price of a complementary good or service causes a shift (increase) in the demand for the subject good or service. Complements to fish populations in the sport fishing experience include boats, fishing tackle, fuel, life jackets and related items. A relative decrease in the price of these items would shift the demand curve of sport fishermen for

marine species to the right, and consequently the MVP curve of wetlands.

Sports fishing is a luxury activity and would be expected to have a positive income elasticity. As per capita real income increases over time, we would expect shifts to the right in demand curves for sport fish populations, and consequently in the MVP curve for wetlands.

Changes in tastes and preferences can cause shifts in demand curves. As more individuals experience the aesthetics of sport fishing, they may demand more such experiences per time period, all other factors being equal. They may introduce friends to the experience as well. The consequence would be a shift to the right in the demand for sport fish populations, and consequently for wetlands products. Population increases may also increase fishing demand.

All of the factors mentioned above could have the effect of increasing the implicit demand for ecologically productive wetlands. Given an inelastic supply of wetlands, the consequence of these demand shifts is increased value of wetlands per acre. Figure 12 illustrates successive shifts in the MVP of wetlands from  $MVP_0$  to  $MVP_1$  to  $MVP_2$ , as income increases, population increases, tastes change in favor of sport fishing, the price of complements decrease.

If social benefits imputed to wetlands are measured as the area under the demand curve to the left of the supply curve, successive shifts in the MVP for wetlands causes increases in the net social benefits attributable to wetlands.

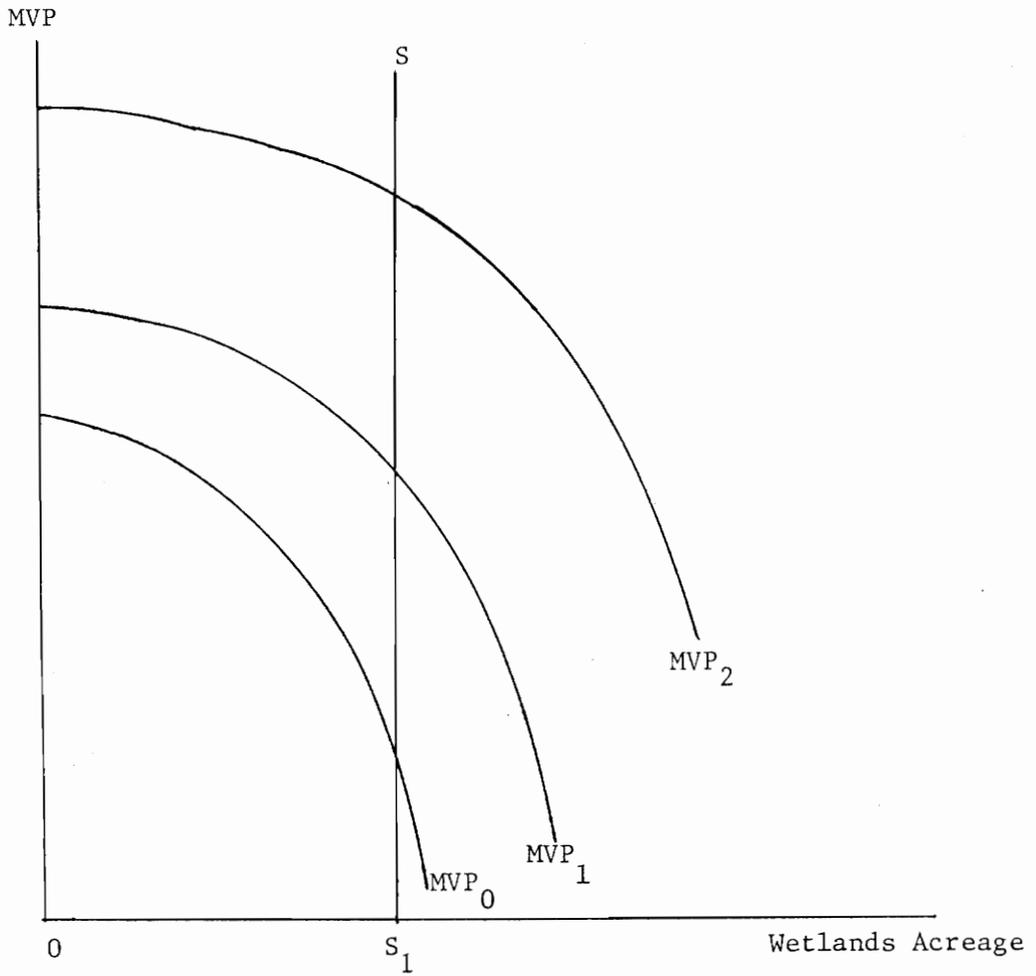


Figure 12. Shifts in the Demand Curve for Wetlands Services.

If the variables which shift the demand for ecologically productive wetlands are increasing at an increasing rate, then net social benefits attributable to ecologically productive wetlands are increasing at an increasing rate. This is a partial restatement of the Schultz hypothesis.

#### Measuring Shifts in Demand for Wetlands Services

For purposes of exposition, full excludability and appropriability was assumed in the case of marine species for sport fishing and wetlands ecologies in a production function for marine species. In reality, marine species are largely open access resources, and the ecological productivity of wetlands has many of the characteristics of Samuelsonian public goods.

For these reasons, direct estimation of demand (and supply) functions for marine species and/or wetlands productivity applying regression analysis to market data is impossible. However, estimation of demand for sport fishing experiences may be possible, using methods similar to those applied elsewhere in recreation studies.

In this approach, the quantity measured on the horizontal axis is man/days of sport fishing activity. On the vertical axis is a proxy for the price of the sport fishing experience, composed of the average cost per sport fishing day, reflecting costs of transportation to the launching site as well as costs of equipment and supplies used in the experience. (See Figure 13.)

Given a demand curve  $D_0D_0$ , changes in the price of complements to fish populations in the sport fishing experience will result in

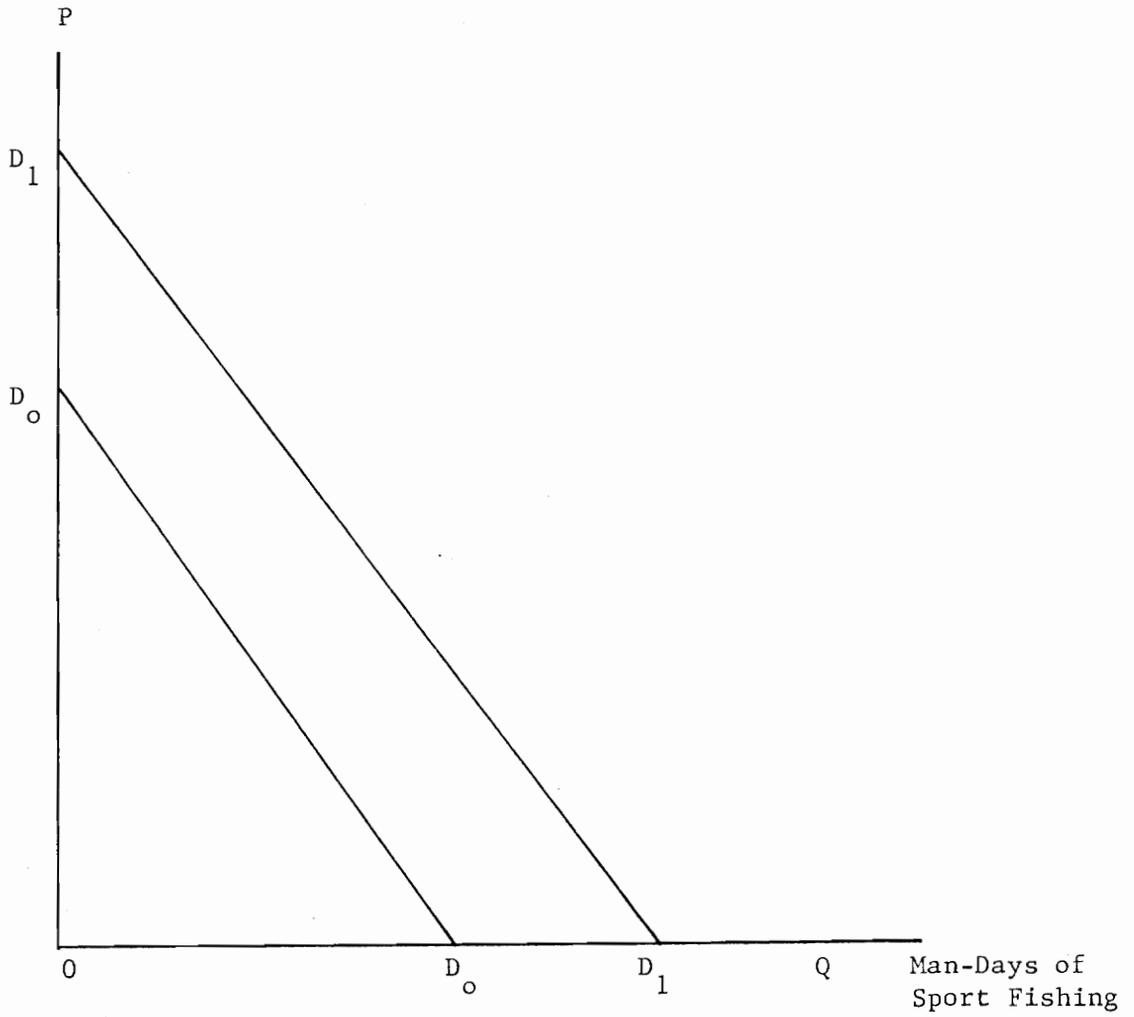


Figure 13. Shifts in a Demand Curve for Sport Fishing.

movement along the demand curve. Changes in tastes, income, and population would be expected to shift the demand curve for sport fishing from, say,  $D_0D_0$  to  $D_1D_1$ .

Any movement to the right on this quantity axis represents a shift in the demand for ecological products of wetlands, i.e., in the MVP curve for the wetlands ecology. Therefore, to test the hypothesis that the demand for ecologically productive wetlands has been increasing, and at an increasing rate, one can estimate parameters in the demand function for recreational sport fishing, and measure the time trend in those variables which determine the demand for recreational sport fishing. Then, using a computational technique to be described later, the time rate of change in the area under the demand curves for sport fishing can be estimated. This value can serve as an approximation of the time rate of change in benefits to be imputed to the ecological products of wetlands.

#### The Importance of Public Perceptions of Ecological Versus Development Values

This chapter has as one of its primary purposes the identification of goods or services from which the implicit demand for ecologically productive wetlands is derived. A second major purpose is to measure time rates of change in benefits to be imputed to the ecological productivity of wetlands.

In foregoing sections, it has been asserted that the demand for recreational sport fishing in the Chesapeake Bay is a principle source of demand for ecological services of wetlands. It was implied that increases over time in the area under the demand curve

for sport fishing would serve as a proxy for the time rate of change in benefits of wetlands services.

These assertions imply that the area under the demand curve for sport fishing is a legitimate measure of total benefits to be imputed to wetlands. Rates of growth in this area, then, represent growth in the total value of all Virginia wetlands acreage, as well as of the average value of an acre of wetland.

It is likely, as economic theory suggests, that some additional wetlands acreage could be destroyed from the standpoint of ecologically productivity without appreciably affecting populations of marine species. That is, the average value imputed to wetlands in preservation uses is probably far greater than marginal values over some fairly large range.

It is also likely that some wetlands acreages in Virginia have far more ecological value than do others. Yet the analysis suggested in the previous section would not differentiate among wetlands acreage.

These limitations of the analysis would represent severe shortcomings if the purpose of the study were to guide decisions concerning allocation of marginal wetlands acreages between preservation and development uses. Such is not the purpose of this study. Rather, the intent is to gain some approximation of the time rate of change in benefits attributable to preservation of wetlands as perceived by proponents of protective wetlands legislation. These values can then be compared to estimates of the time rate of change in benefits imputed to development uses of wetlands.

Some indication of the nature of public perceptions of ecological versus development benefits was reflected in the review of transcripts of public hearings held prior to drafting of legislation (summarized briefly in Chapter II). Representative examples of public testimony suggest that wetlands were regarded to be essential to commercial and sport fisheries, and no emphasis was placed on the distinction between values of marginal acreages and average or total values.

These public perceptions are interpreted as justification for using the time rate of change of total benefits from sport fishing in this analysis as a measure of the perceived time rate of change in values imputed to preserved wetlands. A measure of marginal ecological values of wetlands would be useful policy information, but would not likely reflect perceptions of proponents of wetlands protection. Furthermore, a reliable measure of marginal values for wetlands in ecological productivity would be virtually impossible to establish.

In the following sections, a procedure for computing the time rate of change in total benefits for sport fishing is presented. Drawing upon results of previous demand studies, estimates of these rates of change are computed in an effort to approximate a time rate of change in benefits attributable to Virginia wetlands in preservation.

Demand for Recreational Sport Fishing: Previous Studies

Stoevener, et al., conducted a combined field survey and mail survey of 369 bottomfish angling parties, 120 salmon angling parties, and 69 clam digging parties at Yaquina Bay, Oregon in 1963 and 1964. They specified a demand model as:<sup>1</sup>

$$Q = f(P, I, D)$$

where:

Q = quantity of angling effort, number of angler days per 10,000 population over 12 months,

P = transfer costs per angler day,

I = yearly family income of angler,

D = round-trip distance from the angler's home to the fishery, and

I<sup>2</sup> = squared value of family income.

An exponential demand function was estimated for each fishery, applying multiple regression analysis to natural logarithms of the dependent variables. The distance variable was deleted because of multicollinearity with the price variable.

Results were as follows:

For the bottomfish fishery:

$$\hat{\ln Q} = 8.32341 - 0.68069P^{**} + 0.13274I - 0.01285I^2$$

(R<sup>2</sup> = 0.92)      (0.07366)      (0.12744)      (0.00743)

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<sup>1</sup>Herbert H. Stoevener, et al., Multidisciplinary Study of Water Quality Relationships: A Case Study of Yaquina Bay, Oregon, Special Report 348 (Corvallis, Oregon: Agricultural Experiment Station, Oregon State University, February 1972), pp. 6-11.

For the salmon fishery:

$$\hat{\ln Q} = 5.59954 - 0.69690P^{**} + 0.53153I^{**} - 0.02214I^{2**}$$

(R<sup>2</sup> = 0.95)      (0.0577)      (0.10448)      (0.00490)

(standard errors)

For clamming:

$$\hat{\ln Q} = 8.28347 - 1.17091P - 0.15330I$$

(R<sup>2</sup> = 0.73)      (0.45902)      (0.17442)

Those variables with the double asterisk have coefficients with high statistical significance. Coefficients are of the expected signs in all three cases. The equation for the salmon sport fishery is especially well-behaved, with highly significant coefficients and a high R<sup>2</sup> value. The income elasticity for salmon angling was positive (+1.38), but negative income elasticities were estimated for bottomfishing (-0.24) and clam digging (-0.8).<sup>2</sup> Population growth and the secular increase in per capita income would both tend to shift the demand curve for the salmon fishery to the right. In the clam and bottomfish industries, however, the negative income effects would partially offset the increased demand brought about by population growth.

Assuming no change in the price variable and allowing for projected trends in population and per capita income, the total number of angler days in the salmon, bottomfish, and clam fisheries was

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<sup>2</sup>Ibid., pp. 10-11.

projected to increase by 59.6, 13.2 and 0.6 percent, respectively.<sup>3</sup> For the salmon fishery, the 59.6 percent increase over an eleven year period represents an annual growth rate of about 4.5 percent in the number of salmon angling days taken.

Sport Fishing in the Chesapeake Bay: Calculating the Annual Rates of Increase in Total Benefits

The research effort required to estimate a sport fishing demand equation for the Chesapeake Bay fisheries would exceed the resources available for this study. However, the study of demand for sport fishing opportunities in the Pacific Northwest have produced estimates of relationships between the number of angling days taken and income. Since angling days reported in that study was expressed as the number taken per unit of population, it can be inferred that sport fishing demand increases with population growth, all other factors being equal. On the assumption that the demand relationships for Chesapeake Bay fishing resemble those for Yaquina Bay, estimates of the time rate of change in benefits attributable to the wetlands ecology may be obtained.

Krutilla and Cicchetti suggest a technique for estimating the annual rate of change in benefits attributable to a natural environment. Their technique is predicated on the assertion that the value of any quantity of service consumed per unit of time is measured by

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<sup>3</sup>Results were originally reported in Joe B. Stevens, "Recreation Benefits from Water Pollution Control," Water Resources Research, II (1966), pp. 173-174.

that area under the demand schedule.<sup>4</sup> When the facility providing the service is a reusable, non-depreciating asset, such as a natural environment protected against destruction or degradation, the value of the benefits is the area under the demand curve for each time period the natural area is used.

The Krutilla and Cicchetti example dealt with recreational uses of Hells Canyon and the white water stream running through it.<sup>5</sup> However, their example is analogous to the cause of preservation benefits of wetlands expressed in terms of recreational sport fishing benefits which rely upon the productivity of wetlands.

Growth in income and population over time is reflected in increases in demand for the recreational opportunity and thus, for the natural environment, other factors remaining equal. Since the supply of wetlands cannot be augmented, practically speaking, the annual value of the services would be expected to grow as the demand curve for recreational sports fishing, in conventional analysis, shifts outward in response to income and population growth.

Shifts in a hypothetical demand curve for recreational sport fishing are illustrated in Figure 14. A simplifying assumption would be that the demand curve shifts out uniformly from the origin, but this assumption is modified to achieve greater realism. Taking

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<sup>4</sup>John V. Krutilla and Charles J. Cicchetti, "Evaluating Benefits of Environmental Resources with Special Application to the Hells Canyon," Natural Resources Journal, XII (January 1972), pp. 9-13, 25-29.

<sup>5</sup>Ibid.

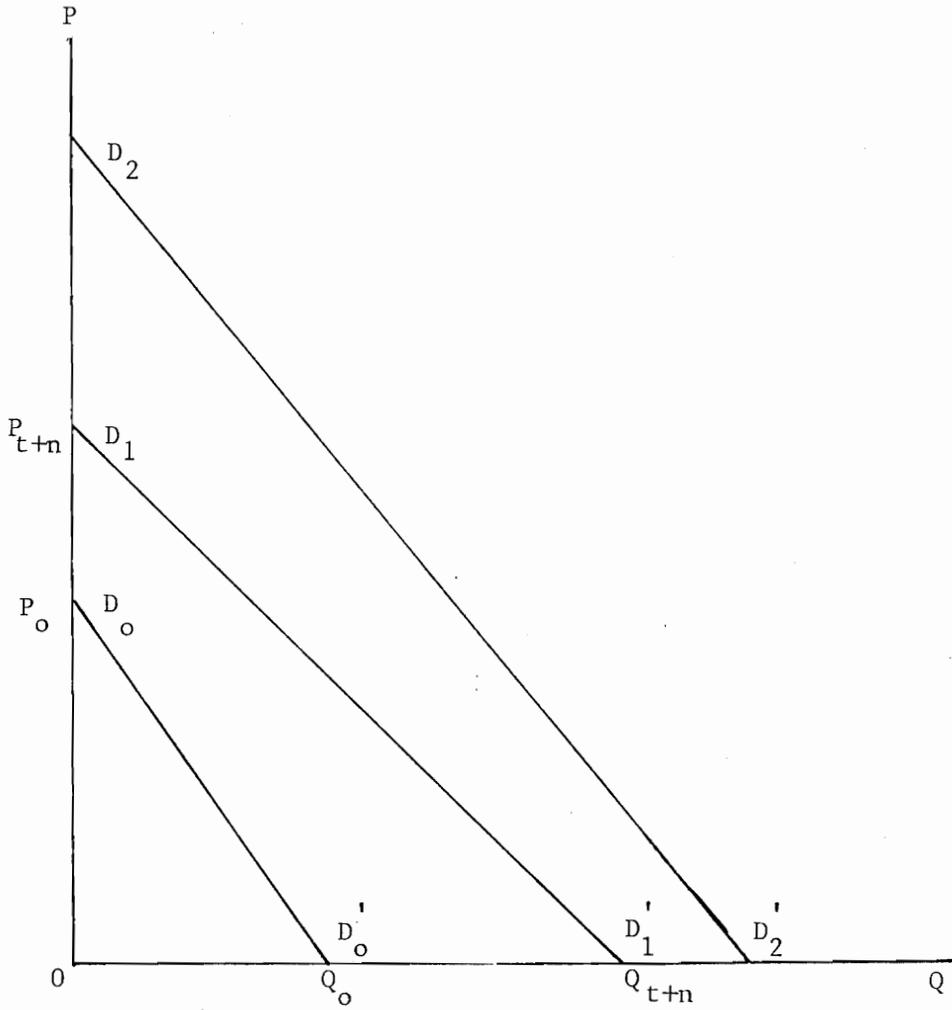


Figure 14. Shifts in a Hypothetical Demand Curve for Recreational Sport Fishing.

available evidence on the growth in demand for recreational fishing, and the income elasticity for this type of activity, the shift in the demand function intercept of the price axis ( $r_y$ ) is related to the growth in real income. The shift along the horizontal axis is related to the rate of growth at zero price ( $\partial$ ), given income and population growth. The resulting shifts produce demand schedules with changing slopes as the area under the curve increases over time.

In Figure 14, the hypothetical demand curve for recreational sport fishing in an initial period is  $D_0 D'_0$ . As income and population increase, the demand curve shifts to  $D_1 D'_1$ . Further income and population changes result in a shift to  $D_2 D'_2$  in yet a later period.

Krutilla and Cicchetti present a computational model for determining the time rate of growth in the area under the demand curve.<sup>6</sup> Their approach may be adapted to the case of recreational sport fishing and changes over time in benefits attributable to ecologically productive wetlands.

Let:

$b_0$  = \$1.00 of initial year's benefits,

$P_0$  = initial vertical axis intercept, (See Figure 14),

$Q_0$  = initial horizontal axis intercept,

$D_0 D'_0$  = initial year's demand schedule,

$r_y$  = rate of growth in vertical component of demand curve shift, related to income growth,

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<sup>6</sup>Ibid., pp. 25-29.

$\partial$  = rate of growth in quantity demanded for  $P = 0$ ;  
i.e., horizontal component of demand shift at  
zero price, related to income and population  
change,

$P_t$  = vertical axis intercept in time period  $t$ ,

$Q_t$  = horizontal axis intercept in time period  $t$ , and

$b_t$  = total benefits in year  $t$ .

then:

$$P_t = (1 + r_y)^t P_o$$

$$Q_t = (1 + \partial)^t Q_o$$

$$b_t = \frac{1}{2} P_t Q_t$$

The parameter of interest to this study is the annual percent in-  
crease in benefits. This is derived as follows:

$$\begin{aligned} b_t &= \frac{1}{2} P_t Q_t \\ &= \frac{1}{2} [P_o (1 + r_y)^t] [Q_o (1 + \partial)^t] \\ &= \frac{1}{2} P_o Q_o [(1 + r_y) (1 + \partial)]^t \end{aligned}$$

but:

$$1 = \frac{1}{2} P_o Q_o$$

therefore:

$$b_t = (1 + r_y \partial + r_y + \partial)^t$$

$$\frac{db_t}{dt} = (1 + r_y \partial + r_y + \partial)^t \ln (1 + r_y \partial + r_y + \partial)$$

The annual percent change in benefits =  $\frac{db_t}{dt} \frac{1}{b_t}$

therefore:

$$\frac{\frac{db_t}{dt}}{b_t} = \frac{(1 + r_y \partial + r_y + \partial)^t L_n (1 + r_y \partial + r_y + \partial)}{(1 + r_y \partial + r_y + \partial)^t}$$
$$= L_n (1 + r_y \partial + r_y + \partial)$$

The rate of change in total benefits from recreational sport fishing is an indicator of the rate of change in benefits attributable to preservation of wetlands,  $\alpha_p$ , given the perceived linkage.

$$\alpha_p = \frac{\frac{db_t}{dt}}{b_t} = L_n (1 + r_y \partial + r_y + \partial)$$

Computation of a value for  $\alpha_p$  derived from changes in the area under the demand curve for recreational sport fishing requires estimates of  $r_y$  and  $\partial$ .

Estimates of  $r_y$  and  $\partial$ , in turn, require estimates of coefficients for variables in the demand function for recreational sport fishing, and data showing income and population growth relevant to the Chesapeake Bay fisheries.

In an attempt to apply the Krutilla and Cicchetti computational technique to the estimation of  $\alpha_p$  (annual rate of increase in preservation benefits of wetlands) derived from Chesapeake Bay sport fishing, the demand equation estimated by Stevens<sup>7</sup> in 1965 for the salmon fishery was adopted as representative of the demand for Chesapeake

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<sup>7</sup>Stevens, op. cit., pp. 173-174.

Bay fisheries.<sup>8</sup> A data series showing the median income for families in the southern region of the United States by years, 1953 to 1974, (see Table 6) was compiled from census data.<sup>9</sup>

As indicated in Table 6, median family income increased from \$6,107 to \$11,230 per year between 1953 and 1974, so that the figure for 1974 is approximately 190% of that for 1953. This represents an average annual rate of increase in median income of about 3%.<sup>10</sup>

The demand equation to which the Krutilla and Cicchetti computational technique is applied is:<sup>11</sup>

$$\ln Q = 5.59954 - 0.69690 \ln P = 0.53153 \ln I - 0.02214 \ln I^2$$

where:

Q = number of fishing days taken per 10,000 population per year,

P = average daily variable cost for fishing,

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<sup>8</sup>A linear, single-equation demand model for the salmon-steelhead sport fishery in Oregon was estimated and reported in: William G. Brown, Ajine Singh, and Emery N. Castle, An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fishery, Technical Bulletin 78 (Corvallis, Oregon: Agricultural Experiment Station, Oregon State University, September 1964), p. 39. It showed a positive correlation between average family income and the number of angling days taken, but could not be used in this study because the model included a distance variable for which no data pertaining to Chesapeake Bay fishing is available.

<sup>9</sup>This region was selected because it includes the states surrounding the Chesapeake Bay and would encompass the area from which most Bay sport fishermen originate. Included are Delaware; Washington, D.C.; Maryland, and Virginia.

<sup>10</sup>Rates of increase may be determined using financial tables for compound interest. See: Samuel M. Selby (ed.), Standard Mathematical Tables (20th ed.; Cleveland: The Chemical Rubber Company, 1972), pp. 635-642.

<sup>11</sup>Stevens, op. cit., p. 173.

Table 6. Median Family Income, Southern Region, 1953 to 1974, in Constant (1974) Dollars.

Year	Median Family Income	Index 1953 = 100
1953	6,107	100
1954	6,108	100
1955	6,602	108
1956	6,801	111
1957	6,881	113
1958	6,992	114
1959	7,359	120
1960	7,300	120
1961	7,267	119
1962	7,534	123
1963	8,059	132
1964	8,463	139
1965	8,767	144
1966	9,620	158
1967	9,946	163
1968	10,467	171
1969	10,903	179
1970	10,861	178
1971	10,934	179
1972	11,396	187
1973	11,793	193
1974	11,230	184

Source: Current Population Reports, Consumer Income, Series P-60, No. 101, Issued January 1976, U.S. Department of Commerce, Bureau of the Census.

$I$  = average family income, and  
 $I^2$  = average family income, squared.

Given the demand equation, we can represent the initial horizontal intercept as:

$$\ln Q_0 = 5.59954 + 0.531531 \ln I_0 - 0.022141 \ln I_0^2$$

where:

$Q_0$  = horizontal axis intercept in initial period, and  
 $I_0$  and  $I_0^2$  = median family income and median family income, squared, in the initial period

and  $\ln P_0$  is assigned an arbitrarily small value greater than but approaching zero.

Similarly, the expected horizontal axis intercept in the terminal year would be:

$$Q_t = 5.59954 + 0.531531 \ln I_t - 0.022141 \ln I_t^2$$

where:

$Q_t$  = intercept in terminal year,  $t$ ,  
 $I_t$  = median family income in terminal year,  $t$ , and  
 $I_t^2$  = median family income, squared, in terminal year,  $t$ .

To estimate the average annual rate of increase in the level of the horizontal axis intercept, values for  $Q_0$  and  $Q_t$  can be computed by plugging natural logarithms of values observed for median family income and median family income, squared, in 1953 and 1974 into the equation for  $Q_0$  and  $Q_t$ , respectively.  $Q_t$  may then be expressed as a percentage of  $Q_0$ . By consulting tables for compounding values, the average annual rate at which the horizontal axis intercept increased

in value over the 22 year period can be identified. This value corresponds to  $\alpha$  in the Krutilla and Cicchetti computations.

To estimate the average annual rate of change in the vertical axis intercept, given the demand equation, it is necessary to transpose the equation and express  $\ln P$  as a function of  $\ln I$ ,  $\ln I^2$  and  $\ln Q$ .

$$\ln P = - \frac{5.59954}{0.69690} - \frac{0.53153}{0.69690} \ln I + \frac{0.02214}{0.69690} \ln I^2 + \frac{\ln Q}{0.69690}$$

$$\ln P = - 8.03493 - .762381 \ln I + 0.31771 \ln I^2 + 1.434931 \ln Q$$

The vertical axis intercept in the initial period is:

$$\ln P_o = - 8.03493 - .762381 \ln I_o + 0.031771 \ln I_o^2$$

and in the terminal period:

$$\ln P_t = - 8.03493 - 0.762381 \ln I_t + 0.031771 \ln I_t^2$$

where  $\ln Q$  is assigned an arbitrarily small value approaching zero.

The average annual rate of change in the level of the vertical axis intercept,  $r_y$ , may be calculated in the same manner as was used for calculation of  $\partial$ .

Using the methods described in the foregoing paragraphs, the following results were obtained:

$$\ln Q_o = 9.846993 \qquad Q_o = 18890$$

$$\ln Q_t = 10.16763 \qquad Q_t = 26000$$

$$Q_t / Q_o = 1.38$$

$$\partial = .0150 \text{ or } 1\text{-}1/2\% \text{ for } n = 22$$

$$\ln P_o = 6.0948 \qquad P_o = 450$$

$$\ln P_t = 6.5549 \qquad P_t = 700$$

$$P_t / P_o = 1.56$$

$$r_y = .0200 \text{ or } 2\% \text{ for } n = 22$$

To account for the affects of population growth in the Chesapeake Bay area on the total value of recreational sport fishing per year, the average annual rate of population growth must be added to the value for  $\partial$  based only on income changes.

Census data indicates that the population of the United States increased from 151,326,000 to 203,212,000 between 1950 and 1970, a factor of 1.34. This is an average annual rate of population increase of 0.0150 or 1-1/2% per year. For the South Atlantic states, which include the Chesapeake Bay states, the population growth rate was higher. Increasing from 21,182,000 to 30,671,000, by a factor of 1.44, the South Atlantic states experienced an average annual population growth rate of 0.0175 or about 1-3/4% per year.

Including the effects of population growth on the rate at which demand for recreational sport fishing increased, the value computed for  $\partial$  is increased by .0150 for a conservative estimate of the effects of population growth, and by .0175 for a liberal estimate of the effects of population growth. Representing the rate of growth in the area under the demand curve as  $\alpha_p^1$  and  $\alpha_p^2$  to distinguish them, the following results are obtained.

Following Krutilla and Cicchetti:

$$\alpha_p = \ln (1 + r_y \partial + r_y + \partial)$$

so:

$$\begin{aligned} \alpha_p^1 &= \ln [1 + (.02) (.015 + .015) + (.015 + .015)] \\ &= \ln [1 + (0.02) (0.03) + .002 + 0.03] \\ &= \ln (1.0506) \\ \alpha_p^1 &= .049 \end{aligned}$$

This value for  $\alpha_p^1$  implies that:

$$b_t = (1 + .049)^t b_o$$

where:

$b_o$  = benefits from sport fishing in base period, and

$b_t$  = benefits from sport fishing in period t.

Given a population growth rate of .0175,

$$\begin{aligned}\alpha_p^2 &= \ln [1 + (0.02) (0.015 + 0.0175) + (0.015 + 0.0175) + 0.02] \\ &= \ln [1 + (0.02) (0.0325) + (0.0325) + 0.02] \\ &= \ln [1.03315]\end{aligned}$$

$$\alpha_p^2 = .052^{12}$$

This value for  $\alpha_p^2$  implies that:

$$b_t = (1 + 0.052)^t b_o$$

where:

$b_o$  = benefits from sport fishing in base period, and

$b_t$  = benefits from sport fishing in period t.

Evaluation of the values for  $\alpha_p$  computed using the Krutilla and Cicchetti computational technique, and the equation estimated for the Yaquina Bay salmon sport fishing experience is difficult. The coefficients estimated in Yaquina Bay case were statistically significant. The population and income data applied to each in the exercise

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<sup>12</sup>Stevens, using the equation reported in the foregoing exercise, predicted an increase of 59.6 percent in the number of annual salmon sport fishing days between 1965 and 1975, assuming a constant price during that period. See: Stevens, p. 173. This suggests that the number of sport fishing days taken was projected to increase at an average annual rate of about 4-1/4 percent. This implies a larger value for  $\alpha$  than that reported for Chesapeake Bay sport fishing.

of this chapter was relevant for Chesapeake Bay areas. By asserting that the demand structure for Chesapeake Bay sport fishing is similar to that of Yaquina Bay salmon sport fishing, it can be asserted that the average annual rate of change in total benefits from sport fishing lies within a possible range of from 0.049 to 0.052.

In any case, it is probable, on the basis of previous recreational demand studies and observed population and income trends, that the preservation benefits of wetlands derived from sport fishing have increased during the past 20 years.

It should be noted that the measure of change in benefits from wetlands preservation derived from the Krutilla and Cicchetti approach represents change in total sport fishing benefits ultimately ascribed to wetlands. This figure is not a measure of marginal values or changes in the value of marginal units of wetlands. It is possible that several thousand acres of wetlands could be destroyed ecologically before any noticeable decline in populations of marine species were noted.

Nevertheless, a measure of changes over time in the average value per acre of existing wetlands provides an indicator of the direction and magnitude of ecological values which may, in turn, be compared to comparable development values for wetlands.

#### Commercial Fishing and Perceived Values for Wetlands

In the first portion of this chapter, the theoretical relationships between ecologically productive wetlands and sport fishing were discussed. For reasons analogous to the sport fishing example, it

can be argued that Virginia wetlands derive a portion of their implicit value from the value of commercially harvested food fish of the Chesapeake Bay.

At least 90% of the Virginia commercial fishery depends on marshland input services.<sup>13</sup> The major dependent species are the oyster, hard clam, blue crab, alewife and menhaden. This dependence is based upon the relationship of marsh vegetation to the food web for marine species, and upon the role of marshes as nursery grounds or protective cover.

Table 7 presents data on annual fish catch and total value of annual fish catch by Virginia watermen on the Chesapeake Bay. There is no clear trend in the dockside value of catch between 1960 and 1971, nor is there a clear trend in total catch over the years. Catch per operating fisherman has been increasing as the number of operating watermen declines and new technology is adopted. Total fin and shell fish harvest averaged about 350 million pounds per year over the twelve-year period from 1960 to 1971.

#### Value of Wetlands as Derived From the Value of Commercial Food Fish

Although the dockside value of the commercial fin and shell fish harvest is a possible measure of the implicit value of Virginia's wetlands acreage, it probably is not a measure which reflects the perceptions of the Virginia voting population or of the

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<sup>13</sup>Marvin L. Wass and Thomas D. Wright, Coastal Wetlands of Virginia, Special Report in Applied Marine Science and Ocean Engineering, No. 10 (Gloucester Point, Virginia: Virginia Institute of Marine Science, 1969), abstract, p. vii.

Table 7. Fishing Effort and Value of Catch, Virginia Operating Units in Commercial Fisheries of the Chesapeake Bay.

Year	Number of Fishermen	Number of Vessels	Gross Tonnage of Vessels	Total Catch (pounds)	Total Value of Catch (\$)	Value Per Pound (\$)	Pounds Per Fisherman	Pounds Per Unit of Tonnage
1960	10,406	790	20,075	289,445,900	16,184,367	.06	27,815	14,472
1961	9,093	820	18,930	283,099,600	19,001,365	.07	31,134	14,900
1962	7,944	661	17,458	363,679,500	16,305,673	.04	45,780	21,393
1963	9,048	759	20,363	320,157,300	14,707,440	.05	35,384	16,007
1964	9,349	723	21,802	390,104,600	19,177,710	.05	41,727	17,732
1965	10,344	900	24,086	436,265,300	20,477,887	.05	42,176	18,178
1966	9,850	945	25,355	358,959,700	16,068,722	.04	36,443	14,358
1967	8,521	895	22,575	322,778,100	15,622,155	.05	37,880	14,034
1968	7,414	843	20,450	350,775,200	16,922,996	.05	47,313	17,539
1969	7,855	852	21,109	223,727,900	14,137,521	.06	28,482	10,654
1970	7,404	839	19,369	478,341,600	16,836,623	.04	64,606	25,176
1971	4,948	824	21,815	379,908,700	16,327,400	.04	76,780	17,269

Source: Fishery Statistics of the United States, Statistical Digest No. 49-65, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, U.S. Government Printing Office, Washington, D.C.

proponents of institutional change. Consumer demand and shifts in consumer demand for seafood are, by definition, indicators of the level and change in relative values attached to seafood. To the extent that the availability of seafood is perceived to be dependent on preservation of ecologically productive wetlands, rates of change in total value of seafood provide a plausible indicator of perceived growth in benefits dependent upon ecologically productive wetlands.

In a study of the demand for fish and shellfish, Raunikar, et al., derived demand relations from an analysis of data reported by a panel of consumers in Atlanta, Georgia, on an annual basis over a five-year period.<sup>14</sup> Demand (per capita and aggregate) is used throughout the Georgia study in reference to quantity of the commodity to be taken by the consumer assuming the availability of supply. This demand, or quantity to be taken, reflects the effects of specified explanatory factors which cause shifts (increases or decreases) in demand and are based on 1965 relations. Specifically, estimates included the influence of household income, household age composition, and race on the demand for fish and shellfish. Regression analysis on cross-section data produced coefficients representing effects of these variables at a given, constant price level, on demand.

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<sup>14</sup>Robert Raunikar, J. C. Purcell and J. C. Elrod, Spatial and Temporal Aspects of the Demand for Food in the United States: V., Fish and Shellfish, Research Bulletin 92 (Athens, Georgia: College of Agriculture Experiment Stations, University of Georgia, June 1971); and J. C. Purcell and Robert Raunikar, Analysis of Demand for Fish and Shellfish (Atlanta, Georgia Consumer Panel), Research Bulletin 51 (Athens, Georgia: College of Agriculture Experiment Stations, University of Georgia, December 1968).

Given coefficients of the estimating equation just described, and using values of explanatory variables gathered from specified localities and regions of the United States, the Georgia study made estimates of fish and shellfish quantities demanded in 1965 on an aggregate and per capita basis by region.<sup>15</sup> Using projected values of explanatory variables for 1980, values for per capita and aggregate fish and shellfish demand were projected for each locality for the year 1980.

The results reported in the study by Rauniker, et al., may be interpreted in the manner illustrated by Figure 15. Price is assumed constant over time, and estimates are made of quantities demanded in each time period, based upon observed 1965 values of variables shifting the demand curve and projected 1980 values for the same variables. Implicit in the analysis is a shift in the demand curve for seafood, from  $D_0D_0$  in 1965 to  $D_1D_1$  in 1980, in response to changes in income, population, and racial mix of populations in the specified region under study during those time periods. Given some constant price level,  $P$ , quantity demanded increases from  $Q_{1965}$  to  $Q_{1980}$  during the time period.

Table 8 presents results of the study for the State of Virginia, District of Columbia, and Maryland; three jurisdictions surrounding the Chesapeake Bay. Results for the United States are presented as a basis for comparison. Of particular interest to the

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<sup>15</sup>See: Rauniker, Purcell, and Elrod, Appendix A, Tables 1-3, pp. 22-26.

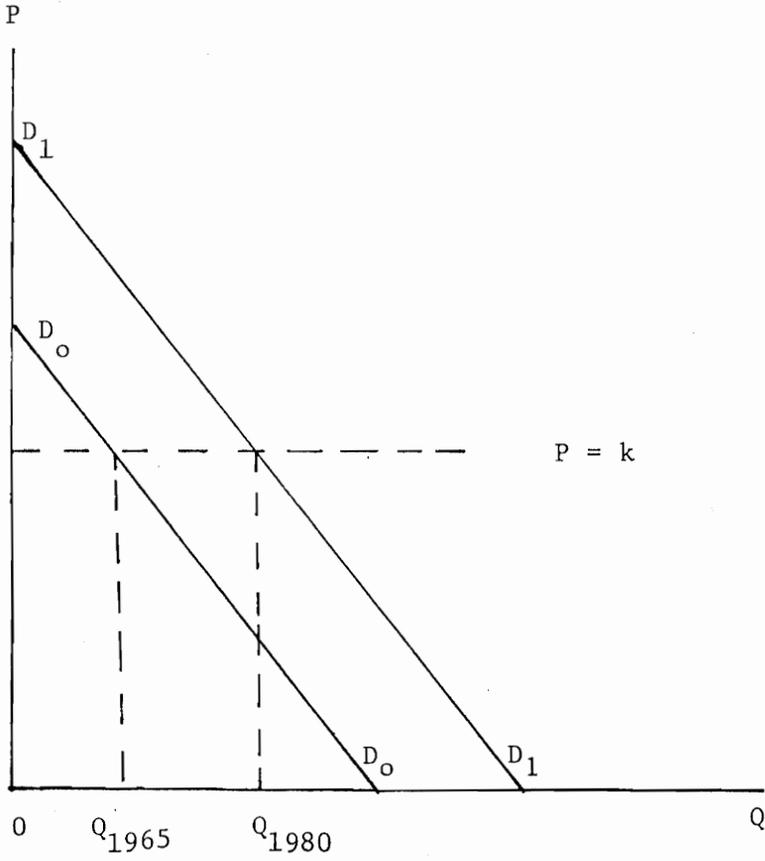


Figure 15. Estimated Demand for Fish and Shellfish, 1965 and Projections to 1980.

Table 8. Estimated Demand for Fish and Shellfish by Locality, 1965 and Projections to 1980.

Locality	Per Capita		Aggregate	
	1965 Relative to U.S. Average	1980 Relative to 1965	1965 mil. lbs.	1980 Relative to 1965
	Index (U.S. = 100)	Index (1965 = 100)		Index (1965 = 100)
Virginia	129	107	34.30	129
District of Columbia	181	119	8.74	148
Maryland	130	109	27.75	139
United States	100	111	1,162.88	133

Source: Spatial and Temporal Aspects of the Demand for Food in the United States, V. : Fish and Shellfish, by Robert Rauniker, J. C. Purcell, and J. C. Elrod, University of Georgia, College of Agriculture Experiment Stations, June 1971, Research Bulletin 92, Appendix A, Tables 1-3.

present study is the index of aggregate demand change for Virginia between 1965 and 1980. The index value of 129 indicates that the total annual quantity of fin fish and shell fish demanded in Virginia (at constant price) will increase by 29 percent between 1965 and 1980.

If it is assumed that the horizontal axis intercept of the seafood demand curve for Virginia increases in value over time at the same rate as the quantity demanded at constant price, then a value for  $\partial$  equal to .0175 may be inferred from the Georgia study.

If it is further assumed that the vertical component of the demand shift is tied to the average annual increase in median family income, a value of 0.0300 for  $r_y$  may be inferred from the results of the Georgia study.

Applying the Krutilla and Cicchetti computational technique to these values for  $r_y$  and  $\partial$ , the following result is obtained:

$$\begin{aligned}\alpha_p &= \text{Ln} [1 + (.0300) (.0175) + (.0300) + (.0175)] \\ &= \text{Ln} (1.048025)\end{aligned}$$

$$\alpha_p = 0.047 \text{ or } 4.7\% \text{ per year.}$$

It is likely that the assumptions concerning values of  $r_y$  and  $\partial$  overestimate both components. At some positive price level, a given increase in quantity demanded represents a larger percentage change than the same nominal increase at zero price (refer to Figure 15 for greater clarity). The rate of change in the vertical component of the demand shift will probably be somewhat less than the rate of growth in income, given a coefficient for income of less than 1 in the equation for the value of the vertical intercept.

To allow for the possible over-estimation of  $r_y$  and  $\partial$  in the foregoing computation,  $\alpha_p$  was computed for values of  $r_y = .0250$  and  $\partial = 0.0100$ .  $\alpha_p$  corresponding to these values is 0.035. This value for  $\alpha_p$  is probably a conservative estimate.

The Georgia study predicts an increase in aggregate seafood consumption from about 34 million pounds to about 44 million pounds between 1965 and 1980 for the State of Virginia. The projected quantity for 1980 represents only about 9 percent of the total fish and shellfish catch by Virginia watermen in the Chesapeake Bay for 1970 alone. The projected increase in demand for seafood by Virginians between 1965 and 1980 will not necessarily tax available annual supplies of seafood.

To summarize, results from the Georgia study of spatial and temporal aspects of the demand for fish and shellfish indicate an expected 29% increase in aggregate annual quantity of seafood demanded in Virginia between 1965 and 1980, based on projected changes in family income, population, and racial mix in Virginia over time, and on an assumed constant price for seafood. The 29% increase in quantity of seafood demanded represents an average annual increase of about 1-3/4% per year over 16 years. Assuming  $\partial$  to equal this rate of change, and  $r_y$  to equal the rate of change in median family income (0.0300), then the total area under the demand curve for seafood in Virginia would increase at a rate  $\alpha_p = .047$  per year. A conservative estimate of  $\alpha_p = .035$  was computed, assuming  $r_y = .0250$  and  $\partial = .0100$ .

### Other Sources of Preservation Benefits

Sport fishing and seafood are two major sources of preservation benefits of wetlands. Wetlands are also credited with additional services of value to society.

Salt marshes create peat beds which have the capacity to absorb extra water and release it slowly after passage of a storm. This capacity of marshes aids in flood protection of coastal areas.<sup>16</sup> In addition to buffering effects from storms and storm tides, salt marshes aid in erosion control and water flow stabilization.<sup>17</sup> The peat beds of salt marshes may also aid in deterring intrusion of saltwater into freshwater aquifers. This attribute could be very important to peninsular areas surrounded by saltwater and subject to heavy use of freshwater supplies.

As habitat for water fowl and certain fur-bearing species, wetlands derive a certain value from sport fowling and fur trapping.

Estimates of levels or trends in these values would be difficult to acquire. However, mention of these values of ecologically productive wetlands is appropriate, if only to demonstrate the broad base upon which the ecological value of wetlands is based.

### Rate of Growth in Preservation Benefits From all Sources Combined

Most of this chapter has been devoted to the problem of approximating time rates of change in areas under demand curves for

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<sup>16</sup>J. A. Steers, "Coastal Changes," Future Environments of North America, Fraser F. Darling, ed. (Garden City, New York: The Natural History Press, 1966), pp. 539-551.

<sup>17</sup>Wass and Wright, op. cit., p. 73.

recreational sport fishing and for seafood in the Chesapeake Bay area and Virginia. The assertion is that these values correspond to those imputed by proponents of wetlands protection to the ecological productivity of wetlands.

Values of  $\alpha_p$  were derived from changes in demand for sport fishing and for seafood. If wetlands are credited with the value of both, then the combined value for  $\alpha_p$  will equal some value between  $\alpha_p$  for seafood and  $\alpha_p$  for sport fishing. There is no concise way to compute a value for  $\alpha_p$  based upon time rates of change in combined sources of value for wetlands without some measure of the levels of benefits. Estimates generated by the study reported in this chapter indicate a combined value for  $\alpha_p$  between 0.035, the conservative estimate based upon demand for seafood, and 0.052 based upon the demand for sport fishing.

The technique employed in this chapter to approximate rates of change over time in values perceived to be attributable to preserved wetlands is admittedly imprecise. It requires strong assumptions about the nature of public perceptions, the relationship between relative perceived values and pressure for institutional change, and the relevance for the Chesapeake Bay of the sport fishing and seafood demand studies cited.

Nevertheless, the evidence strongly favors the conclusion that benefits popularly, and properly, imputed to wetlands in their natural state have increased over time as income and population have increased in the Chesapeake Bay area.

## CHAPTER V

### SUMMARY AND CONCLUSIONS

#### Summary

The case of the Virginia Wetlands Act of 1972 was presented as a problem setting within which to explore the view that some institutions provide economic services, and that pressures for institutional change are associated with changes in demand for these services. An advantage of using the Virginia wetlands problem as the subject of a case study is that it is representative of a larger class of problems dealing with the economics of natural environments.

A general hypothesis to be tested in the case of the Virginia Wetlands Act was that institutional change to assure protection of ecologically productive wetlands was associated with increases in demand for those goods, services, and activities dependent in some way on the ecological services of wetlands. More specifically it was hypothesized that social benefits from preservation of wetlands have increased at a higher annual rate than social benefits from development uses of wetlands.

Review of hearings records for Wetlands Boards in Virginia localities indicate that development demand for wetlands in Virginia has been largely attributable to the demand for waterfront or channelfront residential sites. A large percentage of residential

development activity on wetlands has occurred in the Virginia Beach area.

This research used a case study approach to examine the influence on residential land prices of waterfront situation of residential sites achieved by channeling or filling salt marshland. The market value of land, as used in this study, was defined within the context of an economic theory of rent. A land value comparison technique based upon multiple regression analysis was used to identify market price differentials attributable to waterfront amenities of marshlands as residential sites. Changes in this differential over time were taken as a measure of the time rate of increase in social benefits attributed to development uses of marshes.

For purposes of comparison, estimates were made of the time rate of increase in social benefits attributable to preservation of wetlands. The ecological productivity of wetlands is considered to be essential to maintenance of some marine species in the Chesapeake Bay. A major source of demand for marine species is the recreational sport fishing industry. Using estimates generated by other studies of parameters for the demand for sport fishing, and time series observations on variables which influence demand for sport fishing in the Chesapeake Bay, estimates were made of the time rate of change in the area under the demand curve for sport fishing. By attributing the value of sport fishing benefits to the ecological productivity of wetlands, one estimate was made of the time rate of change in social benefits attributable to ecological productivity of undeveloped wetlands. Then, results of a previous study of consumer demand for

seafood were employed in an attempt to estimate the time rate of change in the area under a demand curve for seafood in Virginia. This value was assumed to be a valid indicator of perceived values of the commercial fishery to be imputed to Virginia's wetlands.

Results of these analyses indicate that the market-imputed value of channelfront situation, imputed to wetlands, increased from an average of \$104 per lot per year in the initial period to \$313 per lot per year in the final period, according to one set of assumptions and based on observations spanning the 21 years from 1955 to 1975. Based on another set of assumptions, the average annual value of channelfront situation per lot increased from \$113 in the first period to \$272 in the final period. These estimates indicate an average annual increase in development benefits per lot ranging from 4.25 percent to 5.5 percent. These values may overestimate values for  $\alpha_d$  perceived prior to 1970, since the price differential attributable to channelfront situation increased dramatically in the final period.

Based on a previous demand study for saltwater sport fishing, and data series for values of variables assumed to shift demand for Chesapeake Bay sport fishing, values for the average annual rate of increase in total benefits of sport fishing ranged from 4.9 percent to 5.2 percent, depending upon which of two measures of population growth was used.

Estimates of changes in the total benefits to be imputed to wetlands from seafood consumption in Virginia ranged from a

conservative estimate of 3.5 percent to a liberal estimate of 4.7 percent as the average annual rate of increase.

In interpreting these results, it must be noted that values estimated for the average annual rate of increase in development benefits,  $\alpha_d$ , apply only to developed wetlands and not to all wetlands in Virginia. The value computed for  $\alpha_d$  represents the annual rate of increase in the average development benefit per lot.

On the other hand, values for  $\alpha_p$  represent the average annual rate of change in total benefits to be imputed to wetlands in preservation uses. The technique by which values for  $\alpha_p$  were computed did not produce estimates of the base values ( $b_o$ ), to which  $\alpha_p$  is applied.

Given the political nature of decision-making for institutional change in this case, it is necessary only that a politically influential portion of the electorate perceive that benefits to be captured through institutional change exceed benefits from development of wetlands in order that an incentive for lobbying exist. Measured benefits, or rates of change in benefits, are meaningful only if they condition perceptions. Testimony before the Virginia Wetlands Study Commission in October 1971, if taken to be representative of the perceptions of proponents of protective wetlands legislation, holds several implications:

1. Proponents of wetlands legislation felt that social benefits lost through development uses destructive of wetlands exceeded benefits to society from development.

2. Proponents of wetlands protection attached the same high value to every acre of wetlands, without perceiving the possible low value of marginal acres.
3. Wetlands ecology was implicitly credited with the total value of commercial and sport fisheries.
4. Wetlands left undisturbed would continue to be productive indefinitely, with a high probability that their value would increase with time.
5. Without legislative intervention, all ecological values of wetlands would eventually be lost forever.

### Conclusion

The hypothesis to be tested was that institutional change in the case of the Virginia Wetlands Act was associated with an increase in the perceived benefits associated with preserving wetlands relative to the benefits associated with development of wetlands. Values estimated for the time rate of change in preservation benefits ( $\alpha_p$ ) and the time rate of change in development benefits ( $\alpha_d$ ) did not lead to the rejection of that hypothesis. Values imputed to unaltered wetlands from sport fishing benefits have increased at a rate equal to or greater than that associated with values of wetlands in development. The values computed for  $\alpha_d$  may overestimate those perceived prior to implementation of the Wetlands Act.<sup>1</sup> If this is the case, then evidence in support of the hypothesis is strengthened.

In addition to values derived from sport fishing, wetlands are credited with other benefits. Among these is the value imputed to commercial fisheries derived from the demand for seafood. Evidence

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<sup>1</sup>For reasons sited in Chapter III.

presented in Chapter IV indicates growth in demand for seafood.

Other benefits associated with unaltered wetlands include those from flood protection, shore erosion control, protection against salt-water encroachment into fresh water aquifers, and wildlife habitat. As residential, commercial, and recreational activities intensity in the coastal region, these values imputed to unaltered wetlands can be expected to increase.

Also, given the practical irreversibility of wetlands alterations, it is appropriate to mention the likelihood that some proponents of wetlands legislation were attempting to satisfy their option demand for the benefits derived from unaltered wetlands. An economic justification for preservation is that many individuals are willing to pay, for example, to retain the option of eating seafood or going sport fishing at some future date, even though they have no current desire to engage in either activity. This option demand has legitimate economic value and could be properly included as a social benefit of preservation of natural areas.

When the probable growth rates of these additional values are considered, the evidence in support of the hypothesis is further strengthened.

Given the nature of political decision processes, it is sufficient to motivate lobbying efforts that citizens identify an opportunity to increase perceived net social benefits by affecting institutional change. This is especially true when citizens perceive an opportunity to increase their own welfare through institutional change. Testimony before the Virginia Wetlands Study Commission

indicates that proponents of protective wetlands legislation considered ecologically productive wetlands to be of increasing importance to social welfare and of potentially large value to future generations.

Evidence presented in this study is generally consistent with the hypothesis that perceived benefits from unaltered wetlands have increased at a faster rate than have benefits attributed to wetlands in development.

#### Implications and Limitations

The hypothesis concerning relationships between institutional change and dynamics of the economy holds implications of importance to those people responsible for deciding whether institutions should be changed and, if so, what type of change should be made. The subject has been treated in this study in terms of political decisions to alter institutions for the allocation of natural resources.

If it is demonstrated that shifts in demand for services provided by institutions creates incentives for citizens to advocate change, policymakers will certainly find it easier to identify those changes in institutions which would satisfy the demand for services. Some capacity to predict the substance and the timing of pressure for institutional change could be derived from a fuller understanding of the function of certain institutions, and of their ability to accommodate economic change.

This study addressed the hypothesis that benefits from preservation have increased at a faster rate than benefits from

development of wetlands. A stronger hypothesis would be that benefits imputed to ecologically productive (undisturbed) wetlands have increased relative to benefits from development of wetlands, so that the level of benefits from preservation at some time prior to 1972 grew to exceed the level of benefits from development. This stronger hypothesis was not addressed in this thesis because resources required to obtain credible measures of actual levels of benefits from preserving wetlands would have exceeded those available for this study. However, given the value of understanding the reasons for institutional change, and given the results of this study, further research into the relationship between economic change and institutional change can be justified.

There is reason to explore the relationship of economic growth to pressures for institutional change. However, other factors should not be neglected. In the specific case of the Virginia Wetlands Act, several factors undoubtedly combined to produce change. For example, a growing attentiveness, nationwide, to the importance of unmarketable and unpriced environmental amenities has been reflected in such federal legislation as the Coastal Zone Management Act. A general climate of greater emphasis on environmental and ecological protection and inducements of federal legislation probably tended to favor institutional change in Virginia. Whether this trend is associated with relative shifts in values of preservation versus development benefits is a question which invites return to the original hypothesis of this study.

It must be recognized that the manner in which changes in relative values affect demand for institutional change depends in part upon the incidence of change, or the distribution of effects, in relation to the locus of political power. This is true because of the political nature of decision-making for institutional change.

The implications of distributional consequences can be illustrated using the Virginia Wetlands Act. The Act requires that the ecological value of wetlands be weighed in all future decisions concerning the use of wetlands. The effects on income distribution of this requirement are not neutral. Those who enjoy sport fishing would expect to benefit from the legislation. In the long run, so could commercial fishermen and consumers of seafood. Current owners of channelfront residential sites might support legislation restricting further development of wetlands, with the expectation that their channelfront property values would increase as a consequence. However, owners of undeveloped wetlands may expect to lose the eventual development value of their acreages if further development of wetlands is prohibited. Some localities may suffer a decline in revenues if bans on development erode the tax base.

Given that the affects the Virginia Wetlands Act on expected income flows were not neutral, it is not surprising that support of the legislation was not unanimous. Non-unamity plus the public good nature of the benefits suggest that, in cases such as the wetlands legislation, benefits to be captured through institutional change must be substantial to induce cooperation among potential beneficiaries for a lobbying effort.

Furthermore, the importance of the incidence of resulting benefits and costs emphasizes that there is nothing inherent in the process of institutional change that suggests a movement toward improved social efficiency. Specifically, government responds to the majority vote rather than to the vote of each individual separately. A voter may deliberately vote for activities which he would impose only on others, knowing that he can, himself, avoid the consequences. Similarly, political decisions for institutional change could benefit a majority to the detriment of a minority, without reference to changes in total social benefits. Therefore, nothing inherent in the democratic process operates to guarantee that allocative decisions will be economically efficient or that they will necessarily tend to maximize net social benefits. Unless the effects of institutional change are neutral with respect to the distribution of income flows, an opportunity to increase net social benefits will not necessarily result in unopposed lobbying for institutional change.

Indeed, it is possible that institutional change to capture some set of benefits for a small, but powerful group could actually result in a decrease in net social benefits. Similarly, the existence of an opportunity to increase net social benefits through institutional change will not guarantee that such a change will occur. The outcome depends not only upon the existence of incentives for lobbying efforts, but also upon the distribution of incentives with respect to political power.

This study has found support for the hypothesis that institutional change to account for the value of undisturbed wetlands was

associated with a relative increase in those values as compared to values of wetlands in development. However, this result cannot properly be interpreted as justification for the specific provisions of the Virginia Wetlands Act of 1972. Institutional change to assure that ecological values of wetlands would henceforth be weighed in land use decisions could have taken several different forms, each with different efficiency implications.

For example, it may have taken the form of a development tax, imposing a tax on any development activity which would destroy marsh vegetation. If the tax were equal to the perceived value of ecological services of wetlands involved, then only those development activities with a higher value would be undertaken. This approach would be indirect in nature; leaving administration in the hands of local officials, and land use decisions in the hands of private land owners.

On the other hand, provisions to assure consideration of ecological values of wetlands could have called for a ban on all activities destructive of marsh vegetation, enforced by a state agency. Such an approach would represent centralized (state level) control of resource allocation by direct methods.

Another possibility might have been purchase of wetlands acreages to be protected, or of easements to restrict use of wetlands in such a manner as to assure continuation of those natural functions for which undisturbed wetlands are valued.

Other forms of institutional arrangements are possible which would assure that ecological benefits of wetlands are represented in

land use decisions. Some are direct and inflexible in their method of application. Some involve centralized decisionmaking by a state government bureaucracy. Others may allow local control of resource allocation. Still others may leave institutional arrangements unaltered, but work within existing land use institutions to change ownership patterns.

No single approach, however, can be justified as superior to others even on the basis of clear evidence that total net social benefits attributable to undisturbed wetlands have grown to exceed benefits from wetlands in development. Justification of a particular form of land use institution will require reference to such considerations as the advantages of local control versus state or federal control, private ownership versus government ownership, direct regulation versus indirect measures, and so forth.

If social efficiency, the maximization of net social benefits, is the goal of society, then some forms of resource institutions will perform better than others. It should be noted that attempts to implement proposals to assure social efficiency may be thwarted for at least two reasons. One is related to the nature of political choice, discussed earlier in this section. In political decision-making, the expected effects on the distribution of income flows may take precedence over efficiency questions. The second reason is that some goods and services which institutions are intended to provide are characterized by certain public goods aspects. They cannot be marketed, so there are no market prices to guide allocation in an

efficient manner. Such is the case with wetlands as part of the ecological system.

Nothing in the provisions of the Virginia Wetlands Act assures that wetlands will hereafter be efficiently allocated between development and preservation. It legislates only that further development will be permitted only on wetlands of lesser ecological significance or on acreages not containing marsh vegetation. Such an approach may result in greater efficiency than would have occurred in the absence of legislation, but the Act does not necessarily assure that marginal value of additional wetlands development equals the marginal value of wetlands preserved.

For example, preserving all wetlands of primary ecological significance and developing only those of less significance suggests that there are no wetlands acres of primary ecological significance that would have higher social returns in development. This is quite doubtful, for the more acres preserved, the less socially valuable is another preserved acre (assuming diminishing marginal productivity of wetlands is part of the ecological system). There is, no doubt, some wetlands acreage, the location of which so enhances its value in development, that it should be developed if social efficiency is used as a decision criterion.

These comments do not impugn the validity of the hypothesis upon which this study focused. Rather they point up an additional relevant dimension of the process and performance of decisionmaking for institutional change.

Several areas for further research are apparent. First, additional studies similar to the one reported in this paper would be useful to verify and elaborate the relationship between specific instances of change in resource allocation institutions and changes in demand for those services which institutional change would favor. To the extent that such studies consistently show institutional response to economic change, the capability for predicting the timing and the source of pressures for change can be enhanced.

Further research exploring relationships between the incidence of income effects, concentration of political power, and the choice of institutional arrangements for resource allocation would do much to aid in predicting the effects of information programs on institutional choice.

Another promising avenue for further research would be exploration of the relationship between actual social benefits derived from resources in alternative uses and perceived social benefits in the same uses. Such information would make it possible to determine likely affects of educational programs on the choice of resource allocation institutions.

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## VITA

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*Roy Ronald Carriker*

ECONOMIC INCENTIVES FOR INSTITUTIONAL  
CHANGE: THE CASE OF THE VIRGINIA  
WETLANDS ACT

by

Roy Ronald Carriker

(ABSTRACT)

The case of the Virginia Wetlands Act of 1972 is presented as a problem setting within which to explore the view that some institutions provide economic services, and that pressure for institutional change result from changes in demand for these services.

A general hypothesis to be tested in the case of the Virginia Wetlands Act is that institutional change to assure protection of ecologically productive wetlands was associated with increases in demand for those goods, services, and activities dependent in some way on the ecological services of wetlands. More specifically, it is hypothesized that net social benefits from preservation of wetlands have been increasing more rapidly than net social benefits from development uses of wetlands which destroy marsh vegetation.

This research used a case study approach to examine the influence on residential land prices of waterfront situation of residential sites achieved by filling or draining salt-marshland. The market value of land, as used in this study, is defined within the context of an economic theory of rent. A land value comparison

technique based upon multiple regression analysis was used to identify market price differentials attributable to waterfront amenities of marshlands as residential sites. Changes in this differential over time are taken as a measure of the time rate of increase in social benefits attributed to development uses of marshes.

For purposes of comparison, estimates were made of the time rate of increase in social benefits attributable to preservation of wetlands. The ecological productivity of wetlands is essential to maintenance of marine species in the Chesapeake Bay. A major source of demand for marine species is the recreation sport fishing industry. Using estimates generated by other studies of parameters for the demand for sport fisheries, and time series observations on variables which influence demand for sport fishing in the Chesapeake Bay, estimates were made of the time rate of change in social benefits attributable to ecological productivity of undeveloped wetlands. Other sources of value for undisturbed wetlands were also noted.

The findings were generally consistent with the view that institutional change in the case of the Virginia Wetlands Act was associated with an increase in the net social benefits associated with wetlands preservation, relative to benefits associated with development uses of wetlands.