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U.S. Army Corps of Engineers

Water Resources Support Center
Institute for Water Resources

Shore Protection and Beach Erosion Control Study:

Economic Effects of Induced Development in Corps-Protected Beachfront Communities

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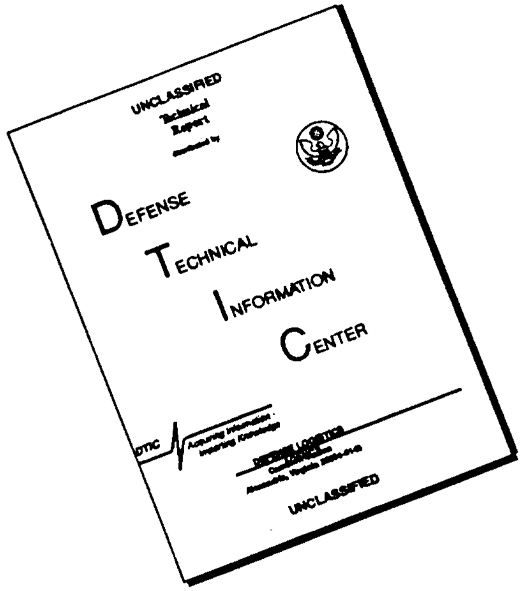

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SHORE PROTECTION AND BEACH EROSION CONTROL STUDY

ECONOMIC EFFECTS OF INDUCED DEVELOPMENT IN CORPS-PROTECTED BEACHFRONT COMMUNITIES

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PREFACE

This report represents an assessment of the relation between Federal shore protection projects and potential induced development in coastal areas. It serves as an input to the final report of a Corps of Engineers study initiated in April 1993 in response to Fiscal Year 1994 "Passback Language" from the Office of Management and Budget requesting an investigation of the Federal shore protection program. Publication of this report was preceded by the issuance of an interim comprehensive cost study by the Corps on the Federal Civil Works shore protection program. The Final Report by the Corps will provide an refinement of the program's costs, and analysis of the benefits, environmental effects, and the existence of induced development resulting from Federal shore protection projects.

This study was undertaken to address concerns that shore protection projects induce economic development in beachfront communities. Using a general model of beachfront economic development, the study was conducted to examine the theoretical relation between shore protection projects and induced economic activity. Following from the theory, three different empirical tests for the relation between shore protection and actual local economic development are implemented. First, residents are surveyed to determine their awareness of and reaction to shore protection projects. Second, a standard econometric model of local area real estate development in forty-two shoreline communities over the 1960-1992 period is estimated considering many variables influencing development, including the extent of shore protection activity. Third, special statistical techniques are used to construct an index of both inland and beachfront housing prices and the relation between shore protection and consequent changes in these prices is estimated.

The study was conducted to fill in a major gap in our understanding of the effects that Federally sponsored infrastructure projects may have on the dynamics of local growth and development. Since there was little explicit literature or research on the subject, a special investigation was undertaken as a cooperative effort between the U.S. Army Institute for Water Resources (IWR) and the George Washington University. In particular, Mr. Michael Krouse, Chief of the IWR Research and Technical Analysis Division, and Dr. Eugene Stakhiv, Chief of the IWR Special Studies Division, agreed to collaborate on this important effort, seeking out proven academic researchers with experience in related economic research.

ACKNOWLEDGMENTS

The research for this report depended on the assistance of a large group of individuals who were directly connected to the formulation, execution, and review of the numerous iterations of this research project. First and foremost, special appreciation is given to Mr. Theodore Hillyer, IWR study manager and Mr. David Hill, IWR task manager, for their attention to the numerous details. We thank Ms. Terresa Allman and Mr. Ethan Wade, both of the George Washington University, for their assistance in data collection and display of the results. Dr. David C. Ling of the University of Florida, Gainesville, and Dr. Dean H. Gatzlaff of Florida State University, Tallahassee, provided the study team with valuable information and constructed the special shoreline residential real estate price indices used in this report.

We would also like to note the valuable contributions of numerous Corps staff who helped to design the study, review the numerous drafts, and who offered constructive critiques of the work as it progressed through the numerous stages. Mr. Donald Barnes and Mr. Harry Shoudy of the Corps Headquarters office were especially helpful and diligent in their roles as project monitors. Mr. Michael Krouse, Dr. David Moser, and Ms. Anne Sudar of the IWR staff provided helpful comments, while Dr. Eugene Stakhiv, Chief of the IWR Policy and Special Studies Division, provided support and oversight for the project. We also thank the personnel of participating Corps District offices in Jacksonville, Wilmington, Atlanta, Norfolk, and New York for providing valuable information and comments on various drafts.

EXECUTIVE SUMMARY

This report addresses the economic relation between Federally sponsored shore protection projects and development patterns in coastal areas. The purpose of the research was to ascertain whether such Federally sponsored projects increased the rate and extent of development in protected areas, i.e. induced development. The results of the analysis are as follows:

- Based upon an analysis and comparison of beachfront communities, with and without Corps shore protection projects, there is no evidence that such projects induce development along the protected shoreline.
- Residents of beachfront communities do not perceive the Corps as the sole source of protection for their erosion or storm damage problems, regardless of whether the Corps is actually active in their beachfront community or not.
- Awareness of the Corps among residents in beachfront communities decreases with wealth and increases with time of residence in the community. This implies that new residents, those economic agents who recently made the investment decision and are affecting the growth and pattern of development, did not explicitly take into account the presence of a Corps shore protection project as a part of their information or rationale used for selecting the location of their investment.
- The existence of a Corps shore protection project is not statistically significant in generating changes in the pattern and growth of development in beachfront communities. Indeed, the significant variables are income and employment, indicators of aggregate economic activity. When the whole economy in a regional coastal area grows, the rate of development in the beachfront community grows as well, with or without a Federal shore protection project.
- No significant effect is observed from Corps shore protection projects on the housing price appreciation rate differential between inland areas versus beachfront areas.

The research was conducted in two stages. First, a model of the determinants of beachfront development was formulated based on economic theory. Second, three independent empirical tests were executed simultaneously in order to evaluate whether such theory actually reflected real world economic behavior. These empirical tests included: a survey of beachfront homeowners, an econometric analysis of forty-two beachfront communities, and a housing price appreciation analysis in selected Florida counties.

Formal modeling of the effects of Federally sponsored shore protection projects yielded a new insight into the nature of induced development. Beachfront communities are in competition with one another to provide a variety of housing and recreation services. If one community receives a protection project, the real estate market responds by *relocating* development from unprotected and inland communities. There may also be some *additional* development in coastal areas due to the increase in safety provided by the project. Overall what is termed *induced* development at the protected beach consists of *relocated* development from unprotected beaches and inland areas and *additional* development. Popular discussion of induced development tends to treat it as additional development, but the additional development component of induced development is actually likely to be very small. To the extent that relocated development comes from unprotected beachfront areas where storm damage probabilities are high and the environment is fragile, it is possible that greater induced development lowers overall expected storm and environmental damage. The distinction between additional and relocated development is subtle, but important in the discussion of policy consequences of induced development effects of Federally sponsored shore protection projections.

Economic theory predicts that effects of Federally sponsored shore protection projects on development occur through changes in expectations of future storm damage and erosion on the part of real estate investors. In order to evaluate these expectation effects, a survey was administered to first and second row homeowners in beachfront communities with different levels of Corps involvement. The purpose of the survey was to collect empirical evidence on the perceptions of residents concerning issues of storm damage, economic losses, and the role of Federally sponsored projects. The report provides descriptive graphical analysis of the survey responses as well as statistical analysis of the data collected.

The effects of Corps projects on beachfront communities were tested directly using a standard econometric model of beachfront development. Using a pooled sample of forty-two beachfront communities over the 1960-92 period (providing a data base of 1386 observations), an econometric model of building permit activity was estimated. The number of units for which annual building permits were issued is used as a measure of the level of new development in a community.

Lastly, the economic effects of shore protection projects were empirically tested using the spatial housing price change approach. Data were collected on the price of houses repeatedly sold over the spatial distance from the beachfront to five miles inland over the time period of January 1971 to December 1992 in three coastal Florida counties. The test was performed to establish the relation between housing prices of inland versus beachfront structures, the rates of appreciation in prices, and to evaluate if the presence of a Corps shore protection project influenced these relations and differentials. The idea, following from the theory, is that housing in protected areas, or areas that become protected, should realize an increase in value due to a lowering of expected loss.

To reiterate, the following can be concluded from the report that follows. The theoretical model, based on the assumption that Corps projects protect the beach and economic assets located there, thus lowering the relative economic costs of one area to another, create opportunity for increased development. This development is composed of development which would have occurred at other unprotected beaches (relocated development) as well as development that would not have occurred otherwise at the same but unprotected beach nor at other unprotected beaches (additional development). Thus, the model theorizes that Corps shore protection projects may induce development. The empirical results, however, indicate otherwise. Agents do not perceive Corps shore protection projects in making their location-investment decisions. Growth in certain areas is occurring regardless of the Corps presence. The real estate market does not perceive Corps shore protection projects as significantly altering the value of structures that are protected. Collectively, these empirical findings indicate that although the model may be theoretically sound, in reality, other reasons as to why agents choose to invest in beachfront property matter more than the potential economic savings generated from being protected by a Corps shore protection project.

SECTION I
THE ECONOMIC ANALYSIS OF INDUCED DEVELOPMENT

Beachfront communities from Maine to Texas have experienced fairly high rates of residential development in comparison to inland communities. For the 42 beachfront communities identified for intensive statistical analysis in Section IV of this report, the average annual rate of growth in housing units over the 33 year period from 1960 to 1992 was 3.9%. This is more than 50% above the average annual growth rate of approximately 2.4% for the entire nation. There is a concern that the high rate of growth in coastal areas may be artificially stimulated by programs of the Federal government, with the National Flood Insurance program and the Federal shore protection program receiving particular attention. This report uses a variety of techniques to understand how and to what extent shore protection programs induce additional residential development in beachfront communities above the level that would be undertaken in the absence of these programs.

Measuring induced development is difficult indeed. Given that Corps projects are evaluated based on potential damage avoided, shore protection efforts are concentrated in areas with considerable past development, i.e. in areas which have experienced rapid growth. Turning again to our data base on 42 beachfront communities, the average annual rate of growth in housing units in the 30 communities that had Corps activity at some time during the entire 1960-1992 period was 4.1% while the rate of growth in the 12 communities where the Corps was not active was 3.8%. This growth differential is to be expected given the criteria used to select projects. However, measurement of induced growth requires that one compare rates of growth with and without or before and after Corps activity. In this same data set, the rate of growth in housing units during periods when there was a Corps-approved project active in a community was only 3.7% compared to 4.9% for years when there was no Corps activity, either because the Corps project had not been authorized or because the Corps was never active in the area. Obviously, for areas receiving Corps projects, the rate of growth in residences was far higher before the Corps project was approved than afterward.

These simple statistics suggest a real potential for confusion regarding the significance of induced development. Shore protection projects are more likely to be approved in areas which are experiencing rapid growth. It is, therefore, easy to confuse cause with effect and to assume that rapid growth is caused by the Corps activity and hence that the growth is all induced development. However, comparison of rates of growth in years after the Corps becomes active with previous growth or with rates of growth in areas never getting a Corps project indicates that induced growth is not significant. Given the potential for confusion, the procedure adopted in this report is to proceed from a careful analysis of induced development using a general theoretical framework capable of showing the interaction between areas with and without shore protection projects and changes before and after a project is approved. Then, a variety of empirical tests are performed designed to determine the way in which the real world reacts to the shore protection in terms of the theoretical framework.

Section II presents a theoretical model of the economic consequences of a shore protection project. The minimum level of complexity necessary to understand induced development requires that changes in the level of development in two beach communities, one with and the other without a project, and in one inland area be considered. A shore protection project lowers expectations for future damage in one beach community. This change should have several consequences. First, it lowers the expected cost of providing beach services in the protected beach community and hence stimulates additional beach use providing a benefit to the general population. Second, the price fall generated by the cost advantage causes development to relocate from both the unprotected beach and the inland area. The consequent increase in economic development in the protected beach area is total induced development and consists of the sum of additional development due to the fall in the price of beach services and relocated development which is shifted away from the unprotected beach and inland areas. Therefore, even if induced development effects are large, measuring the change in expected future damage or environmental effects would require that one differentiate between additional development and relocated development, particularly the relocated development that would have located in the unprotected beach area. Given that shore protection projects cover a small fraction of all beachfront areas, the potential for large amounts of relocated development from unprotected areas is large. Stated in practical terms, a shore protection project at Ocean City, Maryland should relocate unprotected coastal development from Delaware and protection of Virginia Beach, Virginia should relocate unprotected development from the outer banks area of North Carolina. In terms of both expected damage and environmental effects this relocated component of induced development in Ocean City or Virginia Beach is desirable.

Once the theoretical model in Section II is established, the benefit/cost procedures used to justify projects can be evaluated. In addition, the interactions between programs, such as tax treatment of business losses or the National Flood Insurance program, and Federal shore protection projects can be developed illustrating subsequent implications for induced development. The remaining sections of the report focus on the empirical testing of the relations among variables developed in the theoretical model.

Induced development effects are generated by lowered expectations for future flooding and erosion as demonstrated in the theoretical model in Section II. Section III reports the results of a survey of homeowners in beachfront communities where problems of flooding or erosion have been evident in the recent past. The communities include areas with and without Corps projects. The questionnaire was designed with the intent to illicit two primary perceptions of the households. First, to determine if households perceived the local flooding or erosion problems that have occurred in these communities and if they were concerned about these problems. This establishes the importance of expectations of future damage. Second, the questionnaire included a series of questions which were intended to assess the possible relation between the Corps and future expectations for erosion problems. Respondents were asked, in a variety of ways, about the possible role of the public sector in reducing expected future damage and given several opportunities to mention the Corps specifically as a part of a solution to these damage problems. The survey results suggest that the Corps is not widely perceived as an important provider of beach protection, even in areas where Corps projects have significantly reduced erosion problems in recent years. Thus, the presence of an authorized Corps shore protection project does not appear to change perceptions of expected future damage in a fashion that would stimulate significant amounts of induced development.

In Section IV, a standard econometric model of beachfront community residential development is estimated consistent with the theory developed in Section II. Based on a combination of data availability and a primary focus on explaining induced development, a single-equation model is used. The dependent variable to be explained is annual time series data on the number of residential building permits issued during the 1960-1992 period for a panel of 42 beachfront communities. The building permit series is an excellent leading indicator of new residential development. The object of the econometric modeling effort is to separate total new development into the following four categories: induced development associated with the authorization of Corps activity or level of shore protection effort; development based on general growth in demand for services produced in beach areas due to growth in the U.S. economy; development associated with other factors including introduction of the National Flood Insurance program and experience of storm damage in the local area; and the development effects of some local public sector activities such as variation in state regulations. The estimation results show that general growth of real income and employment in inland metropolitan areas are the major driving forces behind beachfront community development. Most indicators of Corps activity have no significant effect on new development and, overall, the estimated effect of shore protection efforts on induced development is very small. It appears that some observers have confused total development in beachfront areas with induced development - i.e. that they have systematically ignored the development effects of general economic growth which is increasing the demand for beach services independent of any government sponsored activities.

Section V describes the final and most elaborate test for possible induced development effects of Corps activity. Using recently developed techniques, a weighted repeat sale house price index is developed for three Florida counties, Dade and Duval on the Atlantic coast, and Pinnellas on the Gulf coast. The resulting index is capable of producing estimates of the annual rate of appreciation in the price of beachfront residences over the 1971-1992 period. At the same time, the annual rate of appreciation for inland properties can also be estimated. If Corps activity has a significant effect on the beachfront residential real estate market, this should be easily seen as an increase in estimated price appreciation in beachfront areas compared to inland areas. The results of these estimates are consistent with the larger econometric modeling effort. There is no statistically significant effect of the level of Corps shore protection activity on the rate of house price appreciation of beachfront properties.

SECTION II
ECONOMIC THEORY AND INDUCED DEVELOPMENT

INTRODUCTION

Shore protection projects lower the potential economic losses to owners of properties located in coastal areas that are subject to storm damage and/or beach erosion. Reducing such losses not only benefits owners of existing beachfront properties, it also may foster induced economic development in beachfront communities by lowering the overall cost of locating economic activities in areas that are subject to storms. Growth of real income and employment in the U.S. economy provides a very important stimulus to economic development in coastal areas. The forty million dollar average annual Federal expenditure over the last five years for shore protection by the Corps seems insignificant compared to the forces of general economic growth shifting demand for beachfront property. The criteria used to justify Corps projects require substantial prior development, and hence substantial previous growth, in order to gain approval. Because high growth communities are selected for Corps projects, it is easy to confuse continued high growth following initiation of a Corps shore protection project with growth that would have occurred due to the general growth effect without the project.

Given the difficulty of determining reasons for growth, it is understandable that there is some disagreement about the extent to which Federal shore protection programs encourage or "induce" development in coastal areas, as well as about the economic effects of such induced economic development. Critics of current shore protection programs believe that such programs encourage significantly more development in coastal areas, and thereby impose costs on society by increasing the amount of property that is exposed to risk from storm damage and beach erosion. This view is disputed by others who contend that shore protection results in little, if any, induced beachfront development. Furthermore, induced development provides benefits by increasing the amount of capital that is available to produce beachfront recreation services.[1] Therefore, induced development is good, not bad.

Do shore protection projects encourage significant "induced economic development" along beachfronts that would not take place otherwise? How should the induced economic development that can reasonably be attributed to shore protection be evaluated in determining the benefits and costs of shore protection projects?

This section begins to address these broad questions by formulating a general theoretical model of how shore protection affects the location of private investment in coastal areas and at other alternative sites while assuming that there is no general economic growth effect shifting the demand for beachfront location. This model is used to compare the pattern of economic development in coastal areas that would be observed with and without shore protection as well as other programs, notably Federal flood insurance, that lower

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[1] In this section, the term "recreation services" will be used to refer to the variety of activities which are produced in shoreline locations. It may be that these are ordinary residential housing services and that households merely value beachfront location because of the ocean view or excellent air quality. The theory presented here holds for a wide range of types of beachfront areas or different bundles of these beachfront recreation services.

expected economic losses from storms suffered by coastal property owners. As part of this analysis, this section discusses how, in terms of economic theory, induced economic development effects should be treated in arriving at the National Economic Development (NED) measures of project benefits and costs that are used to assess whether public funds should be spent on shore protection. In subsequent sections, data on beachfront development are analyzed to explore how shore protection has affected coastal development in practice.

ECONOMIC THEORY OF SHORE PROTECTION AND INDUCED DEVELOPMENT

To explore the relation between shore protection and coastal economic development, it is necessary to develop a general model that allows one to examine not only how shore protection affects economic development at the beach being protected, but also at other beaches, and elsewhere in the economy. Such an economy-wide perspective is needed in order to properly account for two distinct sources of induced development, as defined below. Because the model is designed to focus on induced development, it is useful to ignore the forces of economic growth in the economy which generate general beachfront development effects even if these forces are primarily responsible for beachfront development. As with any exercise in economic theory, certain strong assumptions about economic agents are made in order to simplify the analysis. The model is set up to explore the circumstances under which substantial induced development may result from shore protection projects. However, theory cannot establish the magnitude of induced development. Subsequent sections deal with the empirical question of measuring the magnitude of the possible induced development effects which are identified in this theory section. It is important that these empirical tests be logically consistent with the theoretical model developed in this section.

Relocated vs. Additional Development

One form of induced development can be termed *relocated development*, which represents development that would have occurred in another beachfront area, but instead is shifted to the protected beach. The other is called *additional development* which consists of development that takes place when shore protection shifts recreation activities from nonbeach areas to the protected beach. The distinction is important. Additional development is a net increase in the total amount of beachfront development; relocated development shifts the location of development from one beachfront area to another, without affecting the total.

Development that is induced by shore protection can have rather different effects on subsequent flood and erosion hazard risks, as well as on environmental burdens, depending on whether the induced development is relocated development or additional development. Relocated development encourages beachfront development to become more concentrated in areas that are relatively well protected. Depending on the risk of storm damage elsewhere on the coast, such relocated development may actually reduce long run storm damage to beachfront areas. In contrast, additional development places more property in beachfront areas where storm and erosion hazards are greater than in the inland area or elsewhere in the economy.

It is important to distinguish between the two forms of induced development in assessing how shore protection affects the overall level of property that is placed at risk from storm damage. For example, if all induced development is implicitly assumed to come from areas that would not otherwise be exposed to storm hazards, one ignores the possibility that induced development caused by the relocation of beachfront activities may actually lower the overall exposure of beachfront property to potential economic loss from storms and/or erosion. In this respect, shoreline protection projects may differ from riverine flood control projects that affect the production of agricultural commodities and/or expand highly competitive industrial sectors. It is plausible to assume that riverine flood control projects will have negligible net total relocation effects so that virtually all induced development caused by such projects represents a net increase in economic development in inland flood plains.[2] For reasons that will be elaborated on below, lowering flood damages in Missouri can be expected to expand agricultural production, and hence spur more development in Missouri flood plain areas, without at the same time causing a significant reduction of agricultural production in Kansas or Louisiana. This case may be contrasted with shoreline protection activities where, for example, protection of the beachfront at Ocean City, Maryland, can be plausibly expected to have significant implications for development of the Delaware coastline. A major implication of the theoretical economic analysis presented below is that the consequences of induced development for overall risk in coastal flood plains may be quite different from the consequences of induced economic development in riverine flood plains.

A SIMPLE ECONOMIC MODEL OF BEACHFRONT DEVELOPMENT

The main elements of a model of beachfront economic development are easily presented in graphical form. The figures illustrate underlying economic relations that are discussed in Appendix II-A, where a formal mathematical model is presented. Although a more general mathematical model is needed to investigate the determinants of beachfront economic development in detail, the graphical model satisfactorily captures relationships among the principal variables of interest, and serves as the basis for further analysis of the effects of shore protection efforts, as well as of Federal flood insurance or other risk mitigation programs.

Beachfront Development in the Absence of Risk Reduction and Flood Insurance

To establish a benchmark for analyzing the effects of programs that reduce and/or mitigate risk, and programs such as flood insurance that shift or spread risk, consider first a model that describes beachfront development in an economy without such programs. To allow for the possibility that induced development can come either from relocated or from additional development, such a model must incorporate multiple coastal locations.

It is useful to start with the simplest case of an economy with two beachfront locations numbered 1 and 2. Location 1 consists of a "beachfront" area which offers immediate beach access but is subject to possible flooding and/or erosion, and an "inland" area which is close to the beach, but far enough from the water

[2] For an example of a study which assumes that all induced development is additional development see Stavins and Jaffee (1990). In this study, it is assumed that the price of various agricultural products grown in floodplain areas is unaffected by the additional supply resulting when additional land is converted from timber to cropland.

so that there is a negligible probability of flooding and erosion over the economic time period relevant for development planning. To simplify the exposition, Location 2 is assumed to have a beachfront only. The two beachfront areas are assumed to be equal in their physical aspects (except for possible exposure to storm damage), and are equidistant from population centers.[3] Thus, there are two locations, and three areas in which beachfront development can take place.

Beachfront development in any of these three areas provides households with access to "beach services" which are defined to be general recreation services that could include swimming, fishing, sunbathing, bird watching, etc.[4] These services are assumed to be provided by combining available land with beachfront structures. Beachfront area, however, is limited at each location, and land suitable for development is limited in supply in each of these three areas, so that the cost of providing a "unit" of beach services in each of the three areas increases with the amount of beach services provided.

The basic relation between the supply of and demand for beach services, and beachfront development is shown by Figure 1. Beach services produced at beachfront areas are indicated by the capital letters $\mathbf{B}_1'$ and $\mathbf{B}_2'$ and those produced at the inland area are denoted by $\mathbf{b}'_1$. The cost schedules, showing the relationship between the level of beach services produced and the cost of an additional increment of beach services (i.e. marginal cost of beach services) are shown as $\mathbf{C}_1' (\mathbf{B}_1)$ and $\mathbf{c}_1' (\mathbf{b}_1)$ at location 1, and $\mathbf{C}_2' (\mathbf{B}_2)$ at location 2. As noted above, it is plausible to assume that the cost of producing an additional increment of beach services rises with the level of beach services provided at each location.

The cost of supplying incremental services depends on several factors. One is the ability of structures located in beachfront areas to produce beach services, another is the cost of beachfront structures. It is this second component of cost that provides the link between storm damages, efforts to reduce and/or shift such damages, and beachfront development.

Storm Hazards and the Cost of Supplying Beach Services

The bottom panels of Figure 1 show how the adjustment to market equilibrium is achieved in terms of the market for structure inputs as opposed to the market for beach services in the top panels of Figure 1. In the absence of risks from storm damage, the cost per unit of beachfront structure supplied at each location would equal the amount needed to allow investors to recover the costs of depreciation on such structures plus earn a competitive return on their investment net of depreciation. Since the desired or competitive return to investments in structures will be the same throughout the economy, if there were no

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[3] Adding an inland area to location 2 complicates the model without changing any of the main conclusions of the analysis.

[4] The model presented in this section is most easily applied to development in beach areas where recreation services, broadly defined, are the primary output being produced with the residential development. For beachfronts in urban areas where beach development is an extension of urban growth, imagine that there is an inland concentration of employment opportunities which is equally accessible to the two beaches.

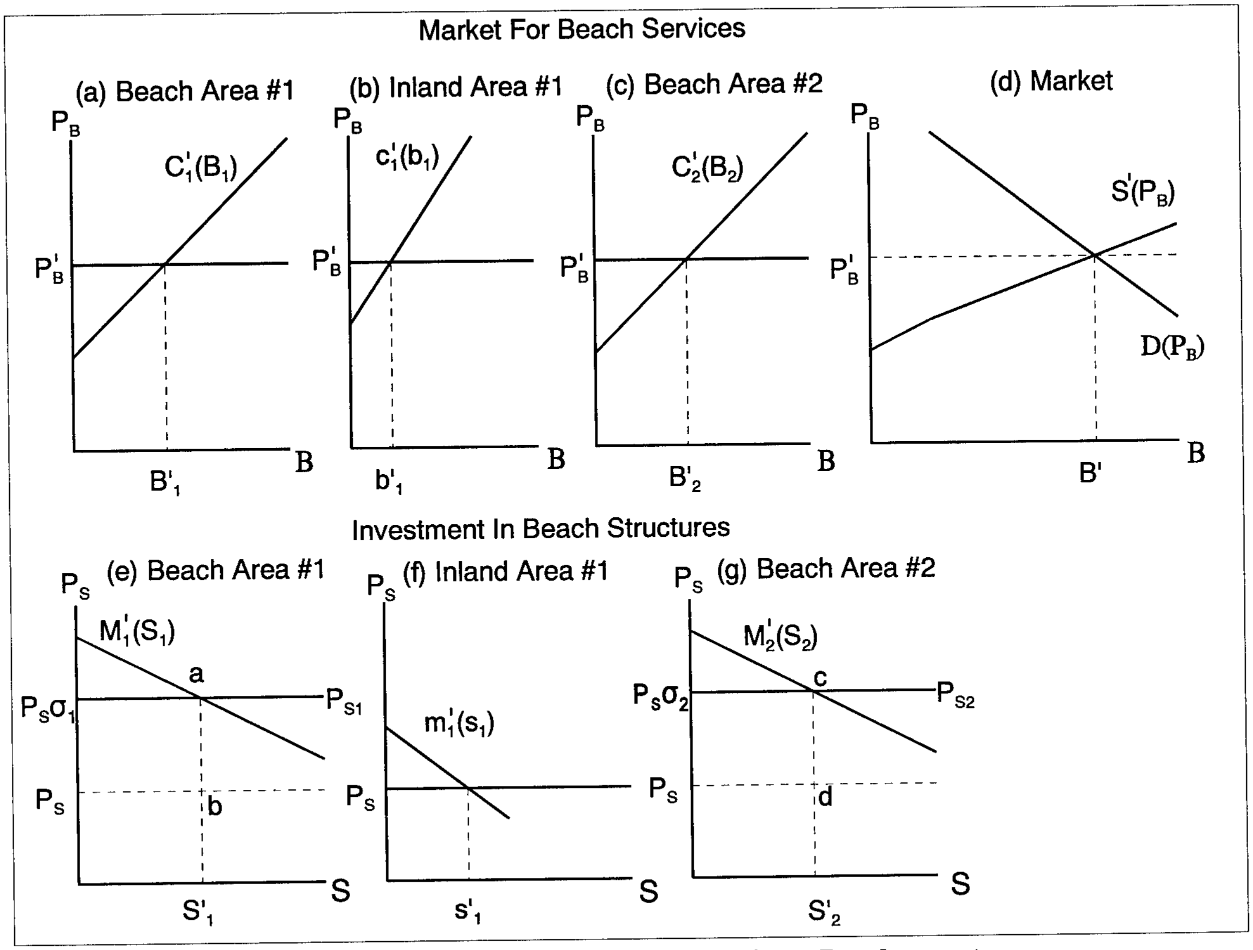

Figure 1 - Baseline Analysis of Beachfront Development

risks from storm damage, investors would be willing to supply as many structures as needed to beachfront areas at a supply price $\mathbf{P_s}$. If the depreciation rate of structures were the same at all beachfront locations, the cost of each additional unit of structures would be the same at all three locations.

If, however, beachfront property is exposed to potential storm damage and/or erosion, the cost per unit of beachfront structures would equal the amount needed to cover depreciation and pay a competitive return, plus an amount sufficient to compensate investors for expected economic losses from storm damages.[5] In this case, if it is assumed that structures located in beachfront areas are exposed to such risks, while structures located in inland areas are not, the price of supplying structures would be $\mathbf{p_{s1}} = \mathbf{P_s}$ in the inland area, and $\mathbf{P_{s1}} = \mathbf{P_s}\sigma_1$ and $\mathbf{P_{s2}} = \mathbf{P_s}\sigma_2$ at each of the two beachfront locations. The term $\sigma_i > 1$ incorporates

[5] For an example of a study that demonstrates the response of real estate markets to changes in expected disaster losses, see Yezer and Rubin (1987).

the premium that must be paid to compensate investors for the hazards associated with expected losses from storm damage and erosion. Thus, in Figure 1, structures in beachfront areas 1 and 2 are assumed to be provided at a price that exceeds the per unit price of structures located in the inland area. The difference between the price of structures in the absence of risk from storm damage, $\mathbf{P}_{s\,i}$, and the price that investors must receive to compensate them for potential economic losses, $\mathbf{P}_{s\,i}\sigma_i$, represented by the distances **(a-b)** and **(c-d)** in Figure 1 is the expected economic loss from storm damage and erosion per unit of structures located in the two beachfront areas.

Note that even though it is more costly to supply structures to beachfront areas 1 and 2, Figure 1 is drawn so that beachfront areas have a net advantage in producing beach services as indicated by the fact that the intercept along the price/cost axis, the cost curves $\mathbf{C}_1' \ (\mathbf{B}_1)$ and $\mathbf{C}_2' \ (\mathbf{B}_2)$ lie below the intercept of cost curve $\mathbf{c}_1' \ (\mathbf{b}_1)$. This outcome is intuitive. Although the risk of storm damage raises the per unit cost of structures located in beachfront areas, relative to the per unit cost of structures located inland, beachfront structures are also relatively more productive than are inland structures in producing beach services.

Figure 1(d) shows the equilibrium between the total supply of beach services available at all three areas and aggregate demand for beach services indicated by the $\mathbf{D(P_B)}$ curve, which shows the quantity of beach services that are demanded at different prices for such services. It is important to note that $\mathbf{P_B}$ is the *price of services at the beach*, as distinguished from the total *cost of going to the beach* which includes costs of time and transportation in addition to the price charged for services at the beach. Factors such as time and transportation costs also affect the demand for beach services, but do so by affecting the shape and position of the entire $\mathbf{D(P_B)}$ curve, i.e. time and transportation costs affect the quantity of beach services that would be demanded at a given price charged for services. The downward slope of the demand curve indicates that for a given level of time and transportation costs, more beach services will be demanded at lower than at higher prices. Clearly, growth of income and employment in the U.S. economy shifts the demand curve to the right over time in a fashion that tends to raise $\mathbf{P_B}$ over time and generate additional development at all locations. However, this general development effect is being ignored here in order to focus on induced development issues.

The overall or market supply of beach services, $\mathbf{S}_\mathbf{B}' \ (\mathbf{P_B})$ is the horizontal sum of the cost curves from each of the three areas. The price per unit of beach services that clears the market, $\mathbf{P}_\mathbf{B}'$ determines the price that providers of beach services can obtain at each of the three locations. The requirement that $\mathbf{P}_\mathbf{B}'$ be equal in all areas in equilibrium follows from the assumption that the beachfront areas are identical in their physical aspects and that they are equidistant from population centers.

As is shown in Figure 1, the market-clearing equilibrium price of beach services $\mathbf{P}_\mathbf{B}'$ determines the equilibrium quantity of beach services that are provided. Thus, total beach service consumption of $\mathbf{B}'$ equals the sum of equilibrium beach service consumption at beachfront area 1, $\mathbf{B}_1'$, at inland area 1, $\mathbf{b}_1'$, and at beachfront area 2, $\mathbf{B}_2'$.

The market-clearing price of beach services, $\mathbf{P}_\mathbf{B}'$, and the productivity of structures in producing beach services in each area together determine the economic return to investment in structures in each area. This relationship is represented by the downward sloping schedules $\mathbf{M}_1' \ (\mathbf{S}_1)$, $\mathbf{m}_1' \ (\mathbf{s}_1)$, and $\mathbf{M}_2' \ (\mathbf{S}_2)$ in the bottom panels of Figure 1. Note that the $\mathbf{M_1'}$ $(\mathbf{S_1})$ and $\mathbf{M_2'}$ $(\mathbf{S_2})$ schedules are both higher than the $\mathbf{m_1'}$ $(\mathbf{s_1})$ curve. This reflects the presumption that an increment of development (investment in structures) will produce more beach services if located in a beachfront area than in an inland area.

The economic return that can be earned from investing in structures and the economic return that investors must receive in order to make such investments together determine both the overall level of beachfront investment, $\mathbf{S'}$, and the pattern of such investment among the three areas, $\mathbf{S_1'}$, $\mathbf{s_1'}$, and $\mathbf{S_2'}$. Note that in Figure 1, owners of structures in all three areas earn the same competitive return, $\mathbf{P_s}$, net of expected economic losses from storms. This requires that the economic return received by owners of structures in the two beachfront areas exceed the economic return received by owners of structures in the inland area, by the amounts **(a-b)** and **(c-d)**, which are the amounts of expected losses from storms.

$\mathbf{S_1'}$ and $\mathbf{S_2'}$ are also depicted in Figure 1 as exceeding $\mathbf{s_1'}$. That is, development is more intense in the two beachfront areas than at the inland area, even though there is a greater risk from storm damage and erosion at beachfronts. Such an outcome is entirely plausible, and is observed in practice. The greater productivity of beachfront structures in producing beach services more than compensates for the greater risk of damage to such structures, over some range of development.[6] The total expected economic losses from storms in Figure 2 equal the shaded area **(a-b)** · $\mathbf{S_1'}$ in beachfront area 1, and the shaded area **(c-d)** · $\mathbf{S_2'}$ in beachfront area 2.

Two features of the equilibrium pattern of economic returns and beachfront development shown in Figure 1 are worth highlighting in the debate about shore protection policies. First, the model indicates that it is quite reasonable to expect well-functioning markets to cause "risky" beachfront areas to be more densely developed than safer areas, even in the absence of shore protection projects and flood insurance. This is because structures located in beachfront areas are capable of producing more beach services per unit of investment.

The model also implies that when investors bear the full economic risk from beachfront development, either directly, or by paying an actuarially fair insurance premium, income tax deductions for casualty losses do not constitute a subsidy for risk-taking, provided that the income from beachfront properties is fully taxed. Rather, casualty losses ensure that risky investments are not "unduly" discouraged by an income tax that claims a portion of the total economic return to an investment, including that portion which compensates investors for expected economic losses. Put slightly differently, when the government shares in the economic returns from beachfront investments by taxing them, it should also share in the losses by allowing full deductibility.[7]

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[6] See, for example, the survey responses summarized in Section III of this report.

[7] The presumption that income from beachfront investment properties is fully taxed was probably not correct prior to passage of the Tax Reform Act of 1986 (TRA), because real estate investments were lightly taxed in the early 1980s. Passage of TRA, however, tightened the tax treatment of income from real estate, both by lengthening the period of time over which taxpayers could claim deductions for depreciation, and by limiting the extent to which investors could claim deductions for so-called passive losses on real estate investments.

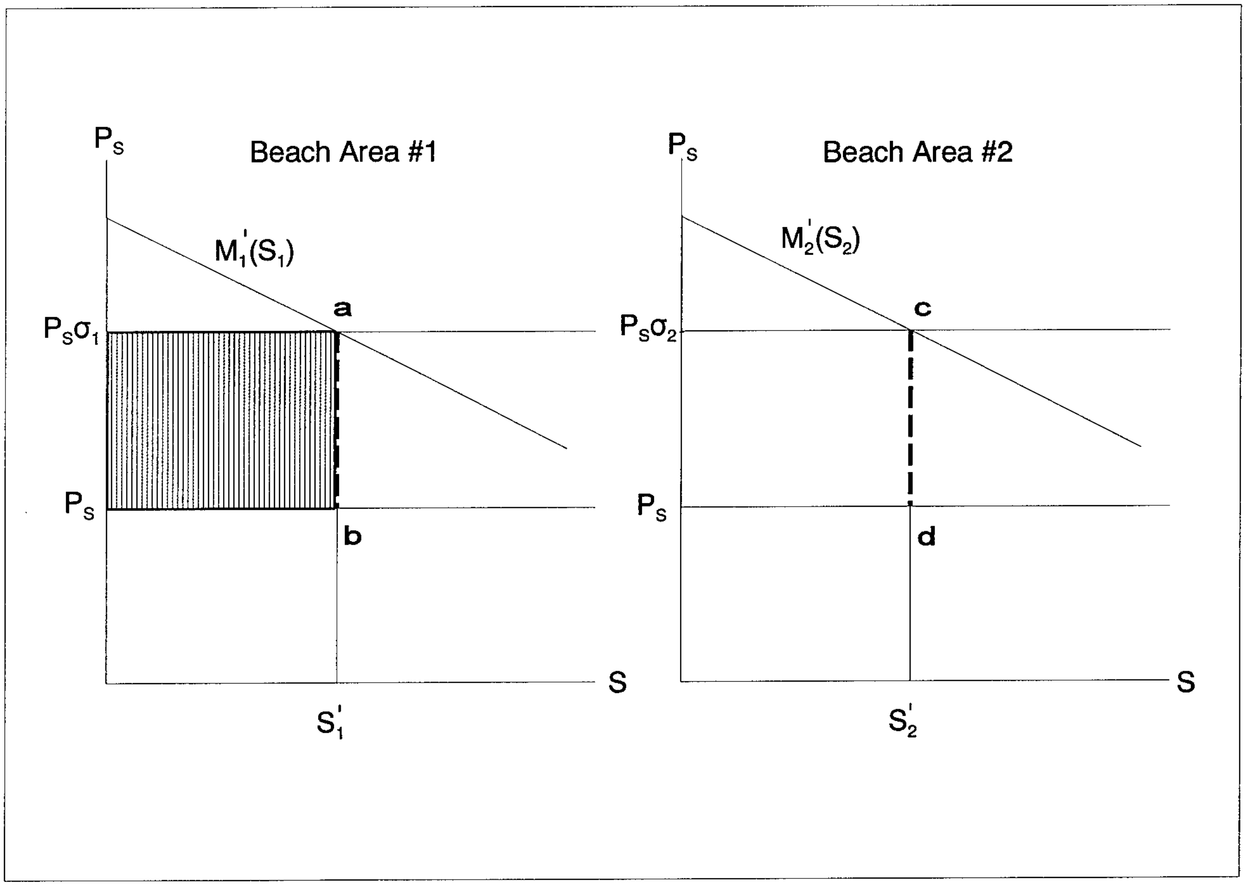


Figure 2 - Expected Economic Loss from Storm Damage

SHORE PROTECTION AND INDUCED ECONOMIC DEVELOPMENT

The model presented in Figure 1 can be used to illustrate how shore protection affects both the pattern and the overall level of beachfront development. In order to separate the effects of programs, such as shore protection, that reduce or mitigate the level of risk, from programs such as flood insurance that shift or spread a given level of risk, first consider how shore protection would affect beachfront development in the absence of flood insurance, e.g. when property owners must self-insure against economic losses from storm damage and erosion.[8]

As noted above, development in beachfront areas that may be induced by shore protection can have rather different implications, depending on whether the induced development represents relocated or additional development. Which of these two sources of induced development are more likely to result depends on assumptions about the market for beach services.

[8] This was the case in years prior to enactment of the National Flood Insurance Program in 1968.

Perfectly Elastic Demand for Beach Services

The extent to which induced development represents a shift of development from nonbeach to beach areas depends on how sensitive the demand for beach services is to changes in price. Figure 3 illustrates the case in which this demand is "perfectly elastic." This means that consumers' demand beach services at a constant price of $\mathbf{P_B'}$. In other words, in Figure 3 it is assumed that, at least over some range, consumers will demand as many beach services as can be supplied by each of the three areas, so long as the price charged for these services is $\mathbf{P_B'}$.

In Figure 3, shore protection is assumed to reduce the risk from storm damage in beachfront location 1. Note that this reduction in risk is shown as a dramatic change on the figure for purely visual purposes. The size of all the theoretical effects shown on this and subsequent figures is an empirical question which will be explored in future sections. The reduction in risk lowers the premium that investors must receive in order to invest in structures that are located in beachfront area 1 from σ_1 to σ_1^*. This lowers the return that investors must receive to compensate them for the risk of economic loss to property located in beachfront area 1 from $\mathbf{P_s}\sigma_1$ to $\mathbf{P_s}\sigma_1^*$, which has several consequences.

A reduction in the return that investors must be paid to induce them to invest in beachfront area 1 reduces the cost of supplying beachfront structural services that are already in place. The amount of the reduction is **(a - a*)**, which equals the reduction in the expected cost from storm damage per dollar of investment in structures located at the protected beach. The drop in expected damages, in turn, lowers the price of supplying beach services at beach area 1 from $\mathbf{C_1'(B_1)}$ to $\mathbf{C_1^*(B_1)}$, and shifts the supply schedule for beach services from $\mathbf{S_1'(B)}$ to $\mathbf{S_B^*(B)}$.

These effects are different manifestations of the <u>same</u> NED benefit from shore protection: reduced economic losses from storms to existing property in the protected area. A direct measure of this benefit would be the total savings in expected storm damage to property already located in beachfront area 1, which equals $\mathbf{(a - a^*) \cdot S_1'}$, or the rectangle **E**. This is the conceptual counterpart to the NED benefit that is measured by the procedures described for determining wave reduction and inundation benefits, and structural damage reduction benefits used to estimated the NED benefits from shore protection projects.[9]

The drop in the cost of supplying additional beach services also makes it financially attractive to provide $\mathbf{(B^* - B')}$ more units of beach services at a price of $\mathbf{P'_B}$, which requires the input of more beachfront structural development. The demand for greater development is accommodated by investors who find it economically profitable to make more investments in beachfront area 1 because the lower expected damage from storms lowers the annual total return that needs to be earned on investments in that location. As a result, there is induced economic development in beachfront area 1 represented by more investment in structures equal to $\mathbf{(S_1^* - S_1')}$.

[9] See *National Economic Development Procedures Manual for Coastal Storm Damage and Erosion*, U.S. Army Corps of Engineers, Sept. 1991.

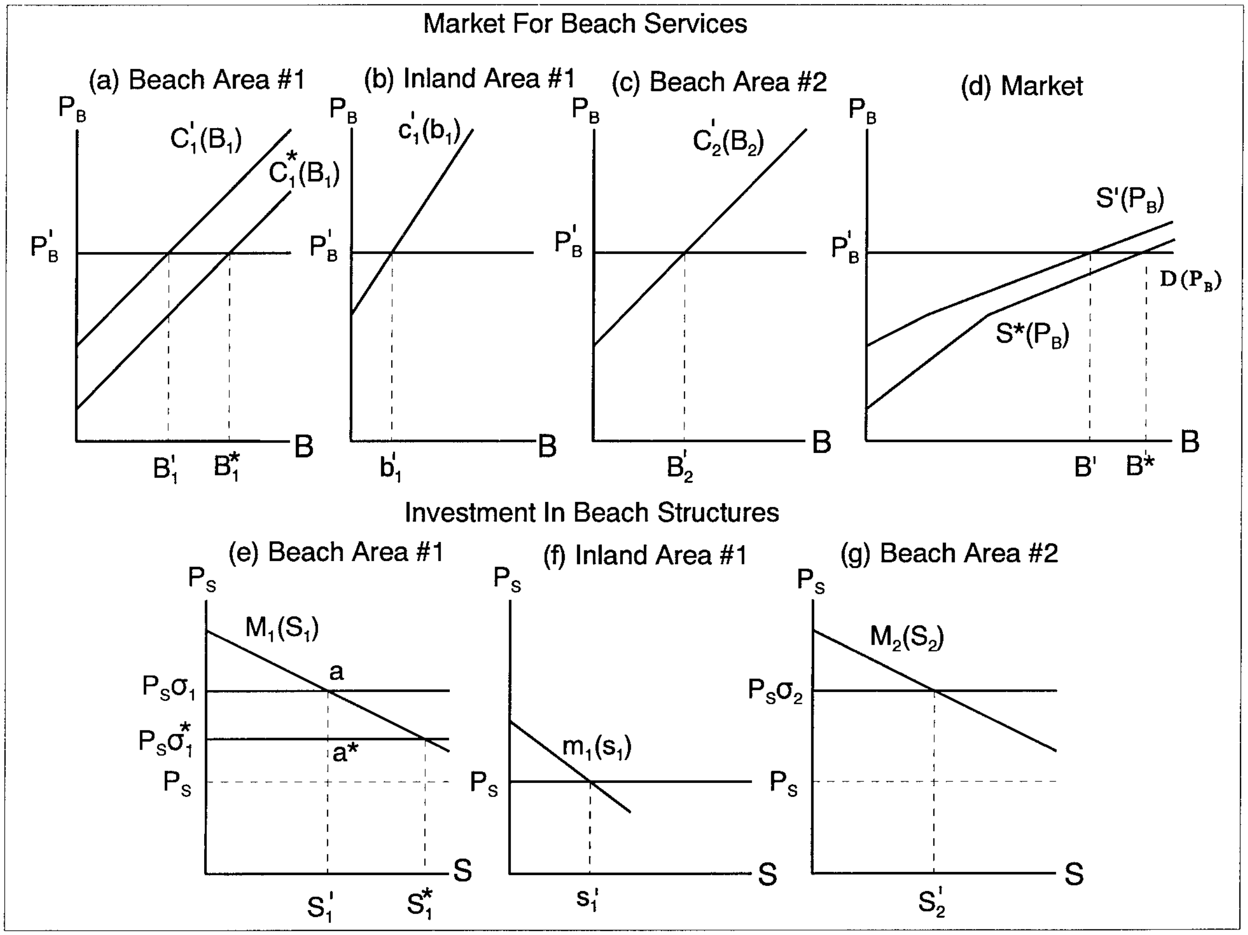


Figure 3 - Analysis of Induced Development with Perfectly Elastic Demand

The Nature of Induced Development

In the case shown in Figure 3, even though there is more development at beachfront area 1, the amount of development at the unprotected beach and inland areas remains the same. As long as beach services are demanded at an unchanging price of $\mathbf{P_B'}$, there is no reason for there to be any less development in unprotected beach areas because investors can still earn the same competitive return as before on investments in these areas. Thus, the development that is induced at beachfront area 1 by shore protection displaces or shifts development from *nonbeach to beach* areas.[10] In terms of the distinction made above, all of the induced development that takes place in beachfront area 1 in Figure 3 is *additional development.*

In this case the net economic effect of induced development in beachfront area 1 equals: [the value of greater production of beach services from additional development in the protected area] - [the value of reduced production from development that is displaced from nonbeach areas to the protected area] - [the

[10] The term nonbeach areas refers to the rest of the economy.

expected economic loss from storm damage to additional development in the protected area]. These amounts are easily shown in Figure 4 which is an enhancement of panels 3(e) and 3(g) of Figure 3. The gross economic benefit from the extra development associated with $(S_1^* - S_1')$ structures in beachfront 1 is the trapezoid **(F + G + H)** under the marginal product schedule, $M_1'(S_1)$. The value of output that could have been produced elsewhere in the economy is the rectangle **H**, which equals the competitive return earned by investments in structures in nonbeach areas, multiplied by the amount of investment, $(S_1^* - S_1')$, shifted away from such areas. The expected economic loss from storm loss due to additional beachfront development is the rectangle **G**, which equals the expected economic loss per unit of investment in structures in the protected area, $(a^* - b)$, multiplied by the amount of induced development $(S_1^* - S_1')$.

The implication of Figure 3 is that induced development in area 1 would provide a NED benefit equal to area **F = (F + G + H) - H - G**. This measure is the conceptual counterpart of the NED benefit measure of location and intensification benefits.[11]

Effects of Induced Development

The analysis indicates that when induced development represents a shift of resources from nonbeach to beach areas it should be counted as a NED benefit of shore protection projects. This view, however, has been challenged by some who argue that induced development should not be treated as an additional benefit of shore protection projects, because such development has the potential to increase rather than decrease the risk of economic loss from storms.

The model presented in Figure 3 shows that an increase in expected storm damage cannot be ruled out. Yet, further examination reveals that the criticism may indicate a misunderstanding of the economic benefits that are provided by shore protection.

The main issues are easily illustrated in Figure 4, an enhancement of panels (e) and (g) of Figure 3. In the absence of shore protection, total expected economic losses from storms in beachfront area 1 equals the amount **(E + D)**. With shore protection, total expected economic losses from storms equal **(D + G)**. The net effect of shore protection on expected economic losses from storm damage equals the difference between these amounts, or, **(G - E) = (D + G) - (E + D)**. Shore protection therefore can result in greater, the same, or lower expected economic losses from storms, depending on whether the area **G** is greater than, the same as, or smaller than area **E**.

This condition has a straightforward economic interpretation. As noted above, area **G** is the expected economic loss on additional development that is prompted by shore protection, while area **E** is the saving in expected economic losses suffered by existing development in the protected area. Thus, shore protection can increase, leave unchanged, or decrease overall exposure to economic loss depending on whether the expected losses from induced development exceed, equal, or are smaller than the expected losses saved on existing development. Of course, the general economic growth effect, in which the demand for beachfront

[11] See U.S. Army Corps of Engineers, *ibid.*

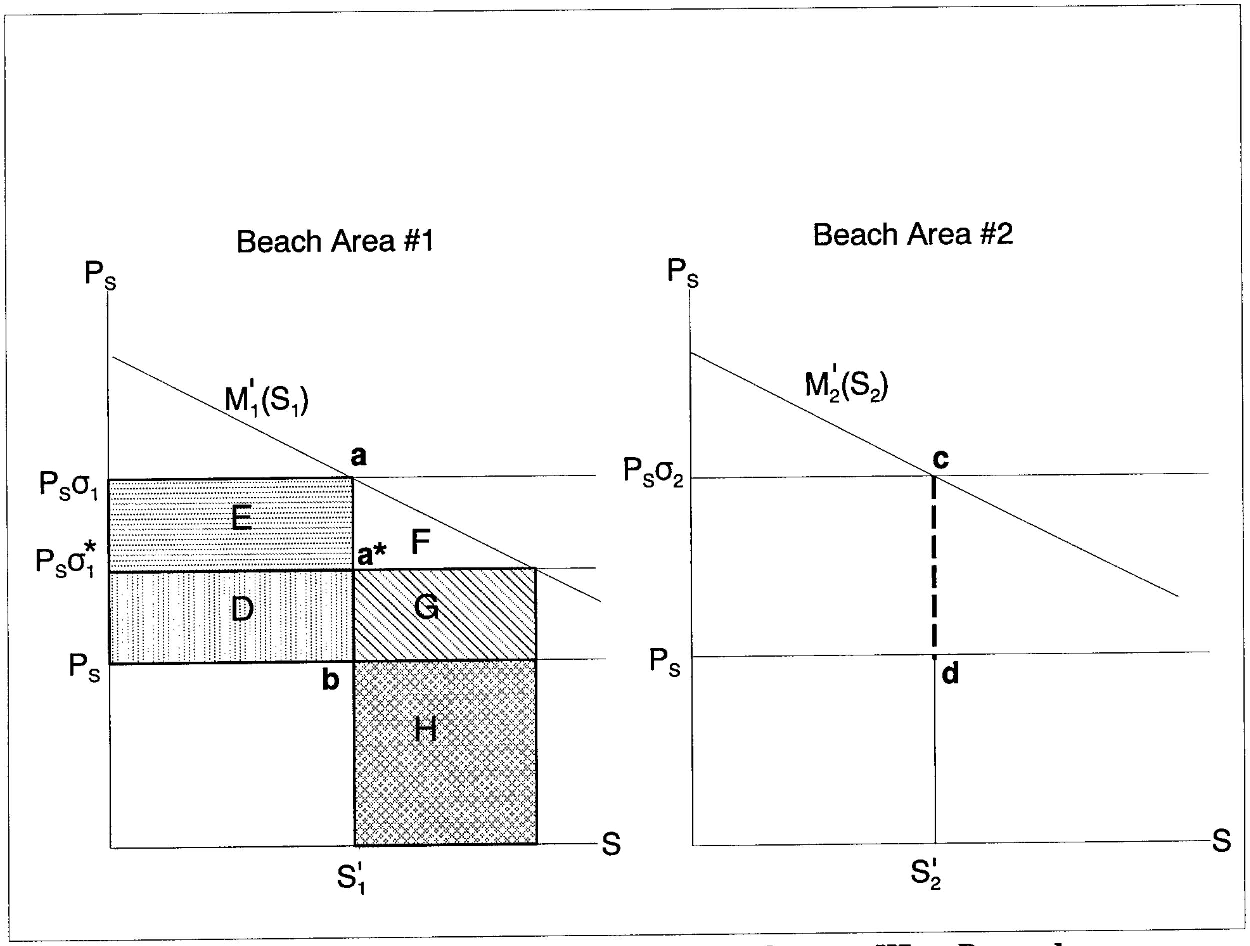


Figure 4 - Economic Benefits of Induced Development When Demand for Beach Services is Perfectly Elastic

services rises over time, results in increased development in beachfront areas that is then subject to potential damage.

Shore protection may, therefore, increase rather than decrease society's expected economic losses from storms in a given beachfront area. This apparent paradox has been highlighted by some critics of shore protection efforts, who contend that the possibility of such an outcome means that shore protection efforts can actually be counterproductive.

This criticism, however, rests on the implicit assumption that the purpose of shore protection efforts should be to reduce economic risk rather than increase economic well-being, as measured by the concept of NED benefits. In terms of the NED measure, the seeming paradox is easily resolved once it is recognized that the increased exposure to risk that is measured by area **G** represents a *voluntary* response to a real reduction in the cost of making investments in beachfront area 1. Investors *choose* to make additional investments in the protected area because the economic return to making such investments is at least as great as the expected economic loss, **G**. In Figure 3, this return (net of the return that could be earned from development in nonbeach areas) equals the area **F + G**.

Viewed in this manner, the NED benefits from induced development in area 1 can alternatively be defined as the sum of the net decrease (increase) in economic losses from storm damage at beachfront area 1, defined by the amount **(E - G)**, and the value of the extra output produced from additional development in the protected area, defined by **(F + G)**. The total NED benefits from shore protection defined in this manner would equal the amount **(E + F)**, which is just the sum of the benefits attributed to a reduction in expected economic losses on existing properties, **E**, plus the value, over and above the expected losses from storms, of induced development, **F**.

Thus, in the case when property owners are assumed either to self-insure, or to pay an actuarially fair insurance premium, when induced development represents a shift in resources from nonbeach to beach areas, the net value of the induced development should legitimately be counted as a NED benefit, even when shore protection increases total expected economic losses. A further implication is that, in the case considered, failure to include the estimates of the benefits associated with induced development will understate the total NED benefits from shore protection.

Perfectly Inelastic Demand for Beach Services

The case that was analyzed in Figure 3 is one in which the demand for beach services are infinitely sensitive to price. Figure 5 illustrates the opposite case in which demand for beach services does not respond to changes in the price. Such a circumstance could arise, for example, if access to a beach were limited by roads and or bridges, so that transportation costs, rather than the price for services at the beach, were the main factors that households took into account in deciding where and how to spend their vacations. Thus, Figure 5 shows the case in which the aggregate demand for beach services is fixed at **B'**.[12]

As in Figure 3, it is assumed that shore protection reduces the risk from storm damage in beachfront location 1. As before, the reduction in risk lowers the premium that investors must receive in order to invest in structures that are located in beachfront area 1 from σ_1' to σ_1^*, which in turn lowers the total return that investors must receive to compensate them for the risk of economic loss to property located in beachfront area 1 from $\mathbf{P}_s\sigma_1'$ to $\mathbf{P}_s\sigma_1^*$.

The initial effects of the drop in the return that investors must be paid to induce them to invest in beachfront area 1 are the same as in Figure 3. The cost of supplying beachfront services that are already in place drops by **(a - a*)**, which equals the reduction in expected cost from storm damage per dollar of investment located at the protected beach. This, in turn, lowers the price of supplying beach services at beach area 1 from $\mathbf{C}_1'(\mathbf{B}_1)$ **to** $\mathbf{C}_1^*(\mathbf{B}_1)$, which shifts the supply schedule for beach services from **S' to S***.

[12] In the presence of perfectly inelastic demand all induced development is relocated development. Note that this contrasts sharply with models such as Stavins and Jaffee (1990) where perfectly elastic demand is assumed.

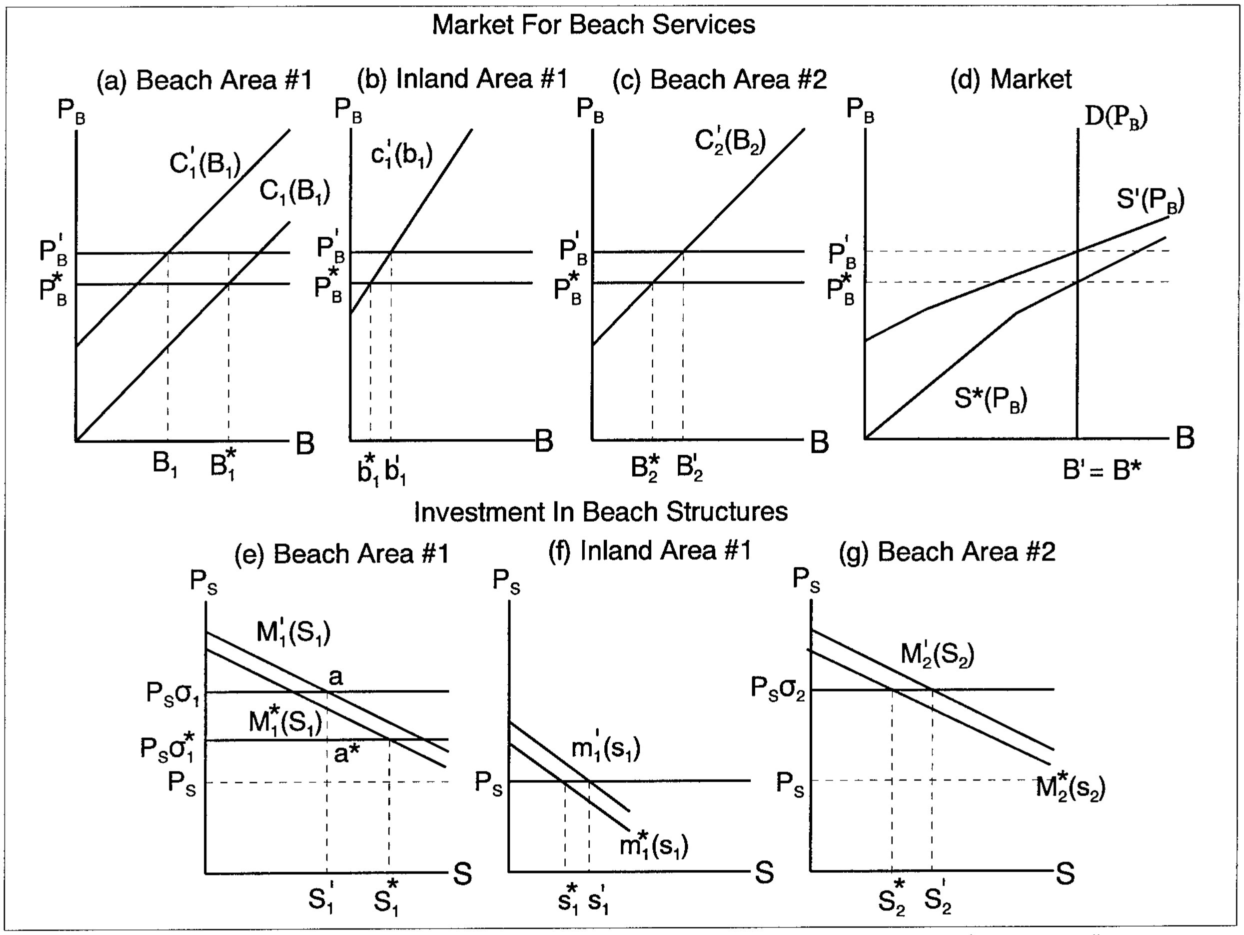


Figure 5 - Analysis of Induced Development with Perfectly Inelastic Demand

As before, shore protection provides a NED benefit equal to the savings in expected storm damage to property already located in beachfront area 1, equal in magnitude to **(a - a*)** · $\mathbf{S_1'}$**.**

Reducing the expected economic damage from storms in beachfront area 1 makes it possible to supply beach services more cheaply. Unlike the case depicted in Figure 3, when the demand for beach services is perfectly elastic with respect changes in **P**, under perfectly inelastic model structure, a drop in the price of supplying beach services leads to a drop in the price of beach services, but no change in the desired quantity consumed. The combination of a drop in the price of beach services from $\mathbf{P_B'}$ to $\mathbf{P_B^*}$, and no change in the total quantity of beach services consumed, leads to the following adjustments in the pattern of development in the three areas.

First, the drop in the price of beach services from $\mathbf{P_B'}$ to $\mathbf{P_B^*}$ shifts the distribution of beach services among the three areas. Beach services provided at the protected beach increase from $\mathbf{B_1'}$ **to** $\mathbf{B_1^*}$ and decrease from $\mathbf{b_1'}$ to $\mathbf{b_1^*}$, and from $\mathbf{B_2'}$ to $\mathbf{B_2^*}$, at inland area 1, and beachfront area 2, respectively. Because the total amount of beach services consumed in all three areas doesn't change, the increase in beach services provided in beachfront area 1 is exactly offset by a reduction in beach services provided in the other two areas, so that $[\mathbf{B}_1^* - \mathbf{B}_1']$ = $[\mathbf{b}_1' - \mathbf{b}_1^*]$ + $[\mathbf{B}_2^1 - \mathbf{B}_2^*]$. The shift in the provision of beach services among the three areas takes place because shore protection shifts the relative cost of producing beach services in favor of the protected beach.

The shift in supply of beach services among the three areas is mirrored by a shift in the location of development. The drop in the price of beach services lowers the economic return that is earned per dollar invested in each of the three areas, which is shown as a downward shift in the investment demand schedules from $\mathbf{M}_1'(\mathbf{S}_1)$, $\mathbf{m}_1'(\mathbf{s}_1)$, and $\mathbf{M}\ (\mathbf{S}_2)$ to $\mathbf{M}_1^*(\mathbf{S}_1)$, $\mathbf{m}_1^*(\mathbf{s}_1)$, and $\mathbf{M}_2^*(\mathbf{S}_2)$ in Figure 5. This causes a fall in development in inland area 1 and in (unprotected) beachfront area 2. In beachfront area 1, although structures earn a lower total return, the economic return that investors need to earn to compensate them for the risk of economic loss from storms is also lower, so that investment in structures rises in the protected area.

Effects of Induced Development

In the case illustrated by Figure 5 the development that is induced in the protected area is relocated rather than additional development. The effect of induced development of this type depends on the extent to which shore protection causes development to relocate from shore areas that have either higher or lower expected losses than the protected beach. In Figure 6, which is an enhancement of panels (e) and (g) of Figure 5, the effect of shore protection on expected economic losses equals the difference between expected damages saved on existing development at the protected beach (and the net additional expected economic losses from induced/relocated development. In Figure 6, the net effect of induced development equals the difference between the expected losses on the additional structures that are located at the protected beach (rectangle **G**) minus the expected losses saved on structures that are no longer located at beachfront area 2 (rectangle **L**). Thus, the total change in expected economic losses from storms in the case illustrated in Figure 6 equals **(G - L) - E**.

When expected losses saved on relocated structures (**L**) exceed expected losses on new structures at the protected beach (**G**), induced development that is prompted by shore protection will actually contribute to a further reduction in expected economic losses from storms over and above the reduction that results from protecting existing property. This outcome is more likely to happen when protection shifts development away from other risky beachfront areas, (e.g. from beachfront area 2 instead of from inland area 1), and when the risk from storm damage at those areas, relative to the risk from storm damage in the protected area (e.g. if **(c - d)** is greater than **(a* - b)**.

Thus, when shore protection causes beachfront development to relocate rather than increase, the effect of induced development on risk from storm damage is theoretically ambiguous. It is necessary to know the patterns of such relocation in order to gauge the qualitative and the quantitative effects of shore protection on total exposure to economic risks from storms.

In contrast, the qualitative effects of induced development on NED benefits are unambiguous. The relocation of beachfront development shown in Figure 5 takes place because investors voluntarily change their behavior in response to the reduction in risk at the protected beach. As in the case illustrated in

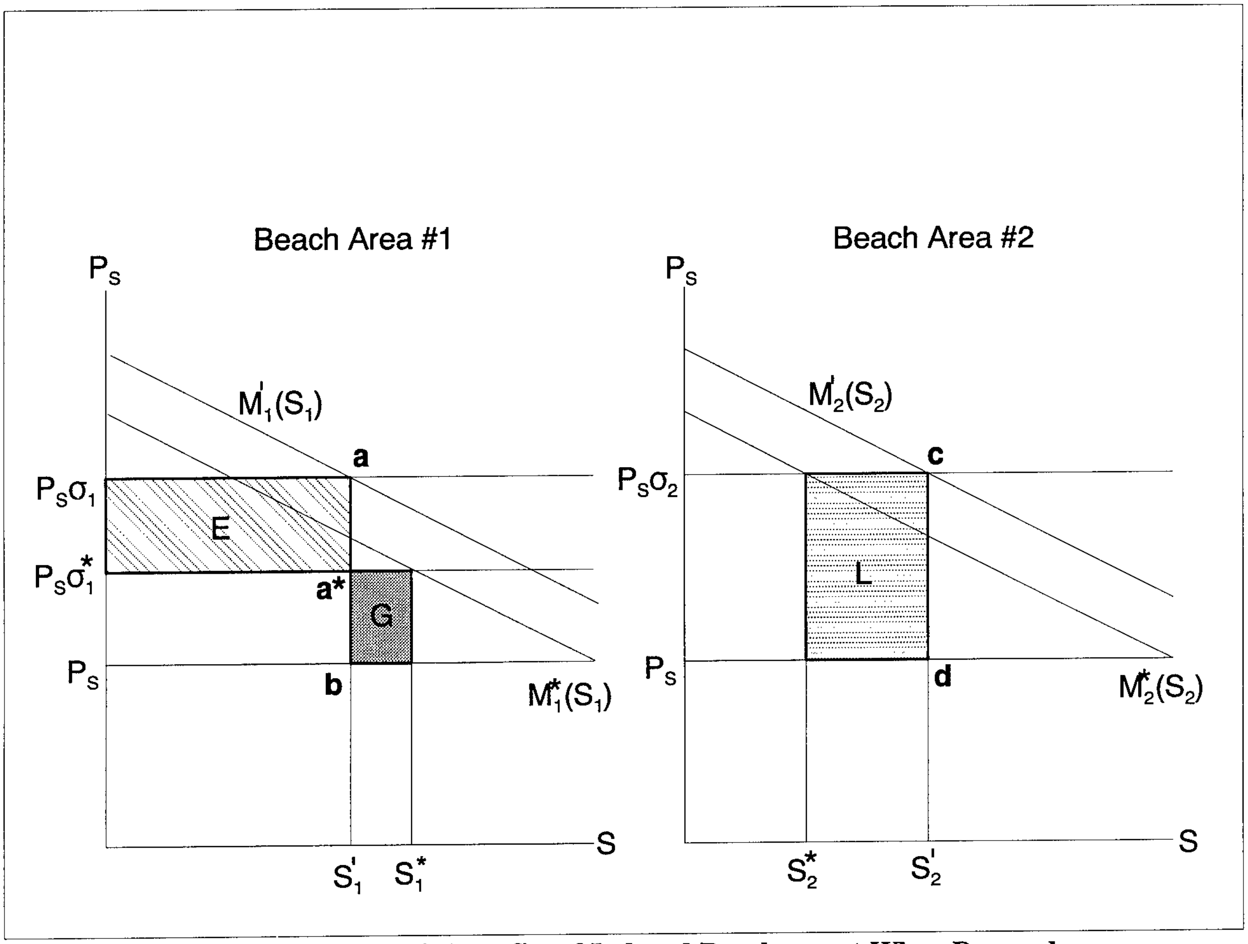


Figure 6 - Economic Benefits of Induced Development When Demand for Beach Services is Perfectly Inelastic

Figure 3, development will relocate to the protected area only if investors can earn an economic return, net of any change in expected economic losses from storm damage, that is at least as great as the net economic return to investments in structures at alternative sites. Thus, as long as owners of properties in beach areas bear the full costs of development, the net value of induced development that comes about from a relocation of investment among beach areas should be counted as a NED benefit, regardless of how shore protection affects total expected economic losses from storms.

Less Than Perfectly Inelastic Demand

In practice, the market for beach services is likely to lie somewhere between the polar cases shown in panel (d) of Figures 3 and 5. The more general case is shown in panel (d) of Figure 7, where the demand for beach services is sensitive to price, unlike Figure 5, but not infinitely sensitive, as is the case in Figure 3.

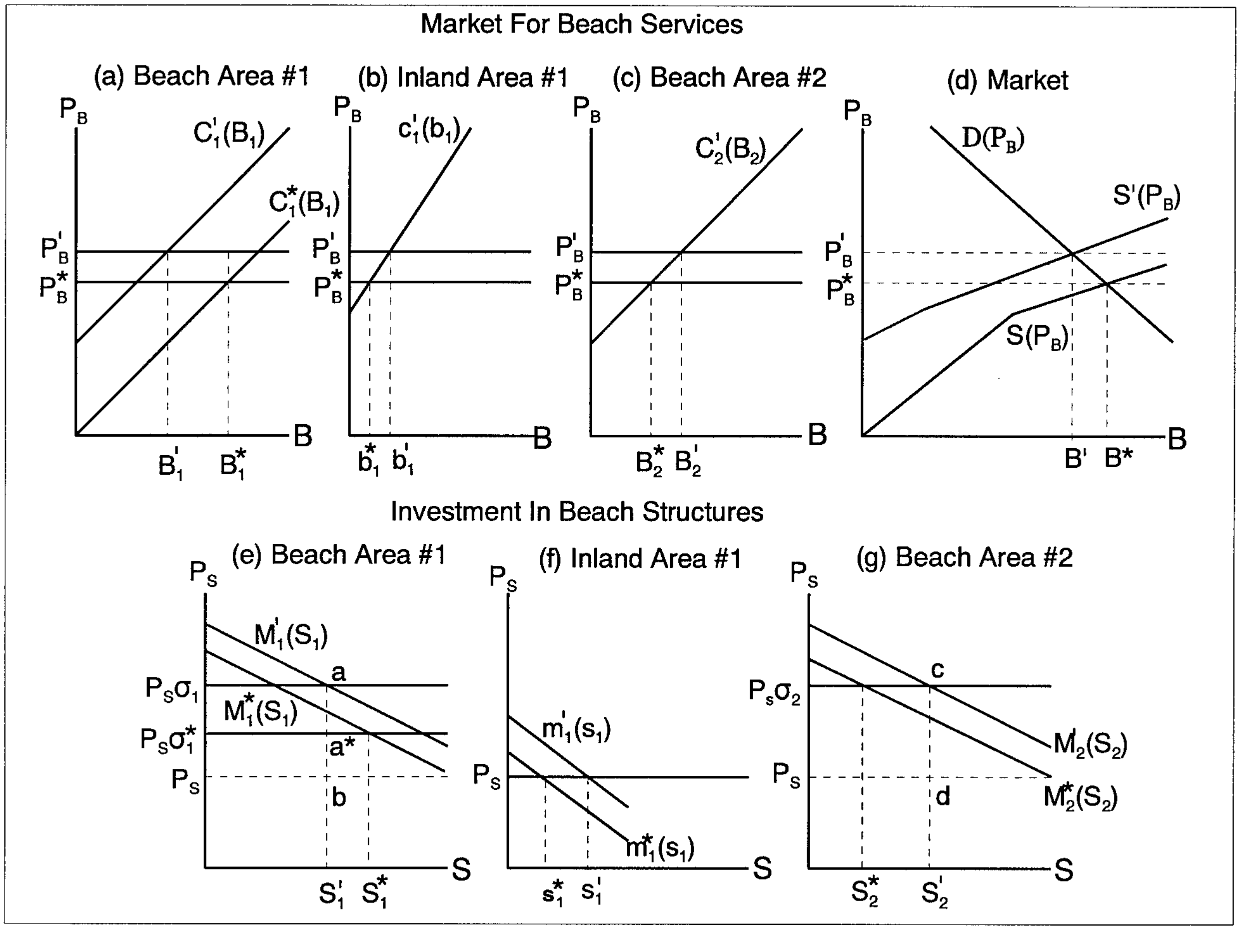


Figure 7 - Analysis of Induced Development with Moderately Elastic Demand

As might be expected, the effects of shore protection in this "intermediate case" combine the outcomes shown in Figures 3 and 5. The induced development which takes place at the protected location (beachfront area 1) is comprised of some additional development that comes from nonbeach areas, and relocated development that is a shift in development from other beach areas.

When induced development is a mix of additional and relocated development, the effect of shore protection on expected economic losses from storms depends on the area from which induced development comes. Induced development from nonbeach areas, or beach areas that are less prone to storms than the protected area, have the potential to increase expected losses from storms. Induced development that comes from beach areas which are more prone to storms than the protected area will have the opposite effect. Notwithstanding these effects, however, when investors bear the full economic costs and benefits of their decisions, induced economic development will be a source of NED benefits, in addition to the benefits attributable to the protection of existing properties in protected areas.

THE ROLE OF FLOOD INSURANCE

The analysis in the previous section has assumed that owners of beachfront property must self-insure against losses from storms. This section extends the theoretical model developed above to explore how flood insurance affects beachfront development, both in its own right, and in conjunction with shoreline protection.

Flood Insurance and Beachfront Development

Figure 8 illustrates the effects of providing insurance against economic loss from storms in the absence of shore protection. Because it simplifies the exposition, without changing the main results, it is assumed that beach services are perfectly elastically demanded, as in Figure 3.

The effects of flood insurance on the pattern of development in beach areas depends on the price charged for such insurance. If property owners are charged an actuarially fair premium, the cost of insurance per dollar of investment will equal the expected value of economic losses from storm damage, or **(a - b)** at beachfront area 1 and **(c - d)** at beachfront area 2. In this case, the total return earned by an investment in a risky location must be high enough to pay investors a competitive return (net of depreciation) after paying insurance premiums of **(a - b)** and **(c - d)**.

Potential investors in beachfront areas 1 and 2 would therefore need to earn total returns of $\mathbf{P_s}\sigma_1$ and $\mathbf{P_s}\sigma_2$, respectively, which are the same returns that they would have to earn if they had to self-insure (when there is no shore protection). The result will be the same pattern of development as depicted in Figure 3 when there is no shore protection and property owners are assumed to self-insure.[13]

Effects of Development Induced by Subsidized Insurance

Economic theory indicates that, if insurance is subsidized instead of offered at an actuarially fair rate, there will be more development in areas that are prone to storm hazards. This effect is shown in Figures 8 and 9 where it is assumed that property owners are allowed to purchase insurance at a price of **fb=fd** "per dollar of structure insured" where **fb** is less than the expected loss from storms, so that buyers of insurance receive subsidies of **(a - f)**, and **(c - f)**, respectively.

Like shore protection, providing subsidized insurance reduces the costs from storm damage to owners of existing property by an amount measured by the rectangle **I** in Figure 9. The availability of subsidized insurance also lowers the return that property owners need to earn per dollar of investment at the two risky areas, which fosters additional development in each of these areas.

However, unlike shore protection which *reduces risk*, providing subsidized insurance *shifts risk* from property owners to others, without reducing it. The distinction is crucial for several reasons. Shore

[13] The provision of insurance on these terms would nonetheless benefit property owners who were risk averse.

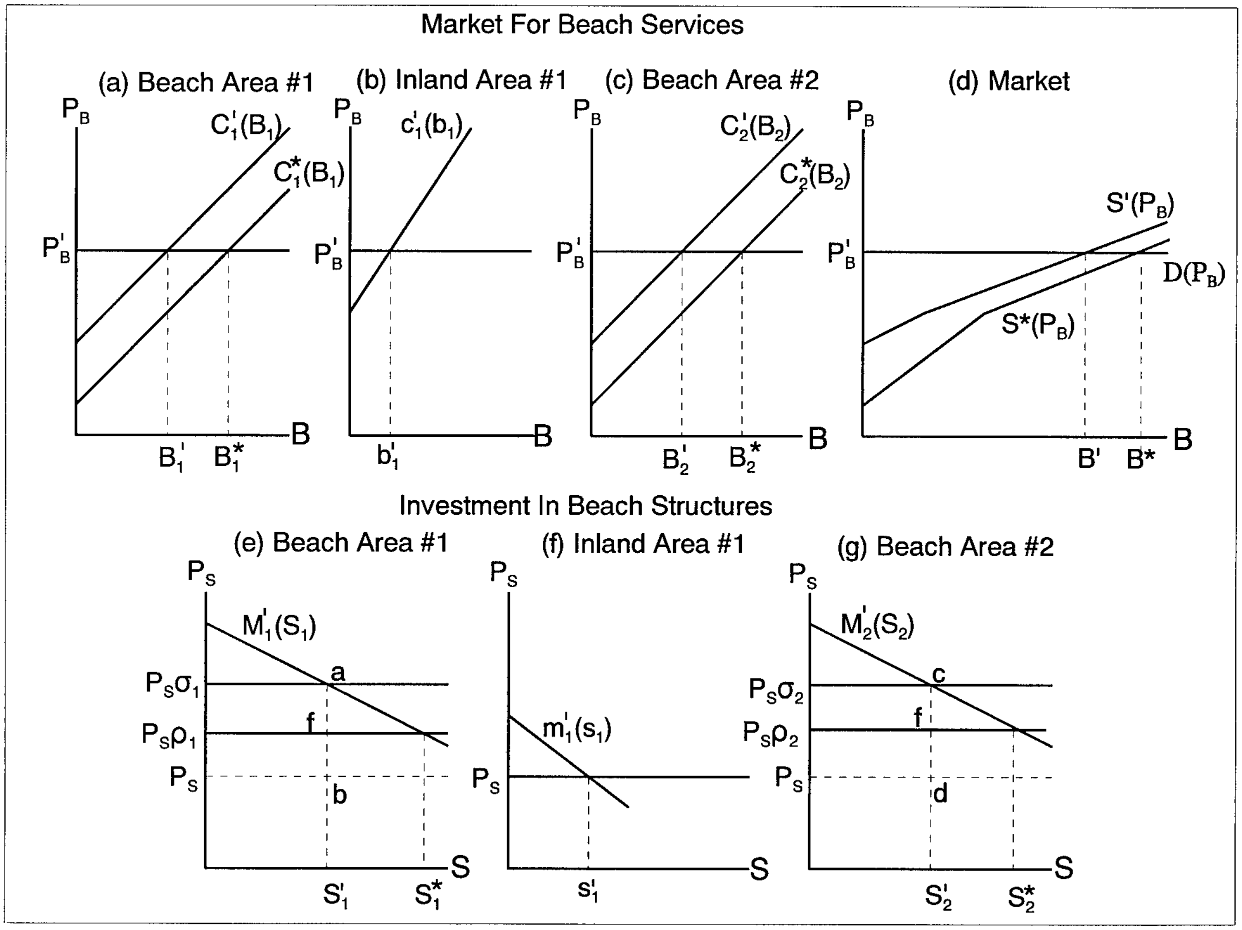


Figure 8 - Effects of Subsidized Insurance on Development with Perfectly Elastic Demand

protection mitigates or reduces expected losses on existing properties, in addition to possibly encouraging more development in areas prone to storms. In contrast, subsidized insurance not only encourages greater development in storm-prone areas, it also does little or nothing to lower the social costs of storm damage to existing properties because the cost savings to property owners measured by the area **I** is an equal and offsetting expense to taxpayers.[14] As a result, offering subsidized insurance is guaranteed to <u>increase</u> expected economic losses from storms.

Moreover, when development is induced by insurance subsidies instead of by shore protection, the expected economic loss to property newly located in beach areas is not matched by an equal or greater increase in the value of additional beachfront output. Instead, the expected economic costs from induced development exceed the benefits, by amounts measured by the triangle **R** at beachfront area 1 and **Z** at

[14] It should be noted that to qualify for Federal flood insurance, property owners are required to undertake protective measures. Many such measures, such as placing structures above-ground, would, however, also be undertaken if property owners had to self-insure.

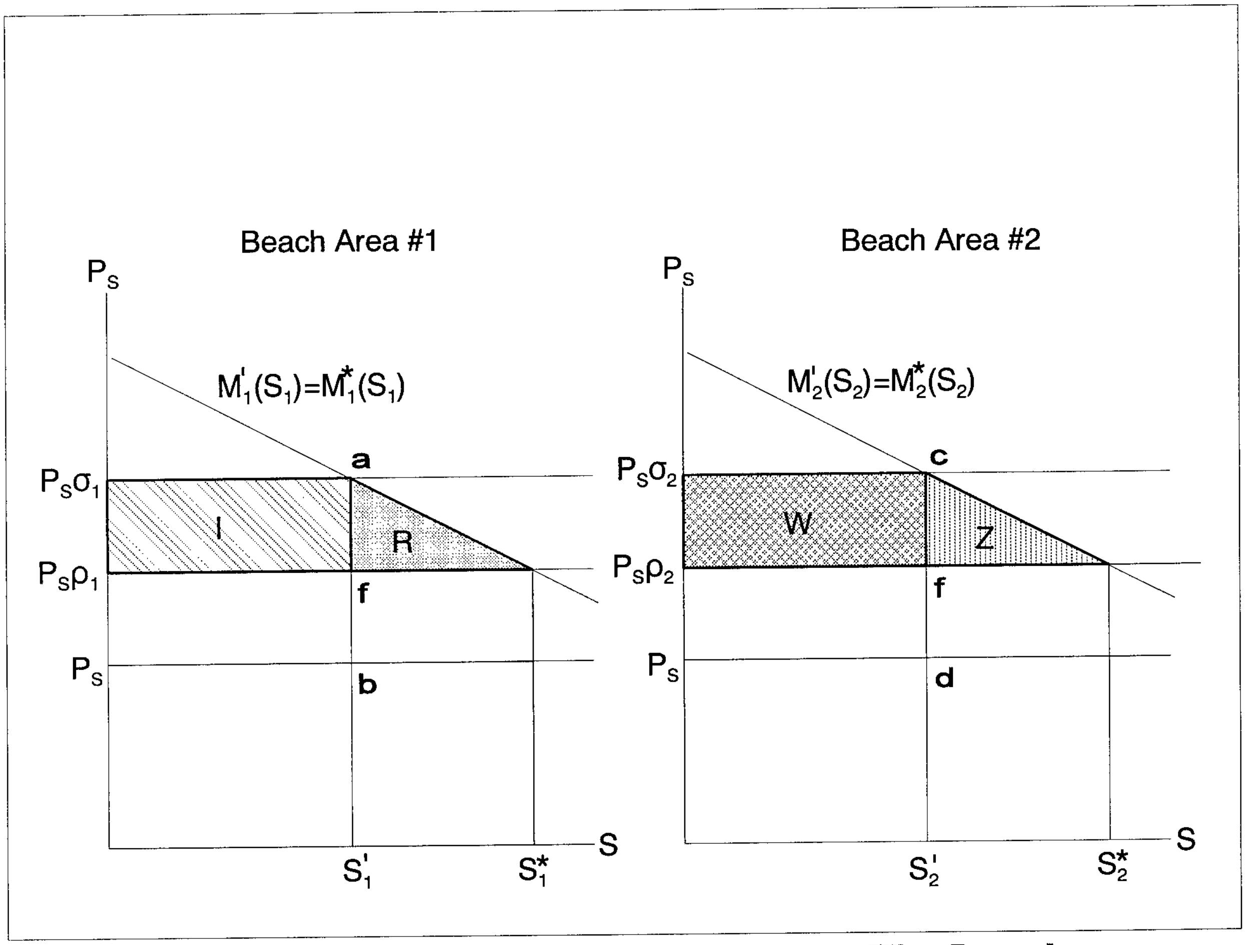


Figure 9 - Economic Benefits of Subsidized Insurance When Demand For Beach Services is Perfectly Elastic

beachfront area 2 in Figure 9. Induced development that is prompted by the availability of subsidized insurance therefore imposes NED costs, unlike induced development resulting from shore protection, which provides NED benefits.[15]

Interaction Between Shore Protection and Flood Insurance

When property owners are able to insure against economic losses from storm damage, the effects of shore protection projects depend on whether the insurance is subsidized. If insurance premiums are based on expected economic losses, the effects of shore protection projects will be the same as when property

[15] When the demand for beach services is not sensitive to price, subsidized insurance will prompt development in beach areas to shift from relatively safe inland locations to riskier beach front locations. Causing development to relocate in this manner also increases expected losses, and imposes NED costs.

owners must self-insure. When insurance premiums are subsidized, the effects of shore protection will depend on two factors. One is the magnitude of the insurance subsidy relative to the reduction in storm risk provided by a particular shore protection project. The other is the extent to which subsidized insurance premiums are adjusted in response to shore protection.

The main results are illustrated in Figure 10, where it is assumed that prior to shore protection, property owners are able to purchase flood insurance at rates of **fb** and **fd** which is less than expected economic losses (in the absence of shore protection) of **(a - b)** and **(c - d)**. Figure 10 illustrates what happens when shore protection reduces expected economic losses from storms in beach area 1 by an amount **(a - a*)** that is less than the initial insurance subsidy **(a - f)**.

In this case, if the insurance premium remains constant at **fb**, shore protection reduces expected losses from storms on property that is already in place at the protected area, but does not induce any additional development beyond the amount that has already been encouraged by the availability of subsidized insurance. The reason is that the amount of development in the protected area is determined by the return that must be paid to investors, which in turn depends on the premium that owners of structures must pay for insurance. If this premium is not affected by shore protection, as is the case shown in Figure 10, there is no financial incentive for further development in the protected area.

A different outcome would be observed if the insurance premium is adjusted downward in response to the drop in expected losses. In this case, shore protection would affect the price of development in beach areas, and induce some further development. Just as in the case shown above in Figure 8, however, the expected economic loss, inclusive of the insurance subsidy, to property newly located in beach areas would not be matched by an equal or greater increase in the value of additional beachfront output. Thus, so long as any subsidy remained, induced development prompted by shore protection would impose NED costs rather than benefits. The source of such costs, however, would be the insurance subsidy rather than shore protection *per se*.

THE ROLE OF ENVIRONMENTAL FACTORS

The analysis thus far has focused on the effects of shore protection on economic risks from storms. It is also possible that development of beach areas may affect the environment. Incorporating these effects in the analysis can affect the conclusions drawn about the effects of induced development.

The main consideration is whether development of beaches imposes external environmental costs that are not reflected in either the price that buyers pay for beach services or the costs of making investments in beach areas. If there are such external costs, there will be too much development in beach areas, in the absence of shore protection projects, because markets fail to account for these costs.

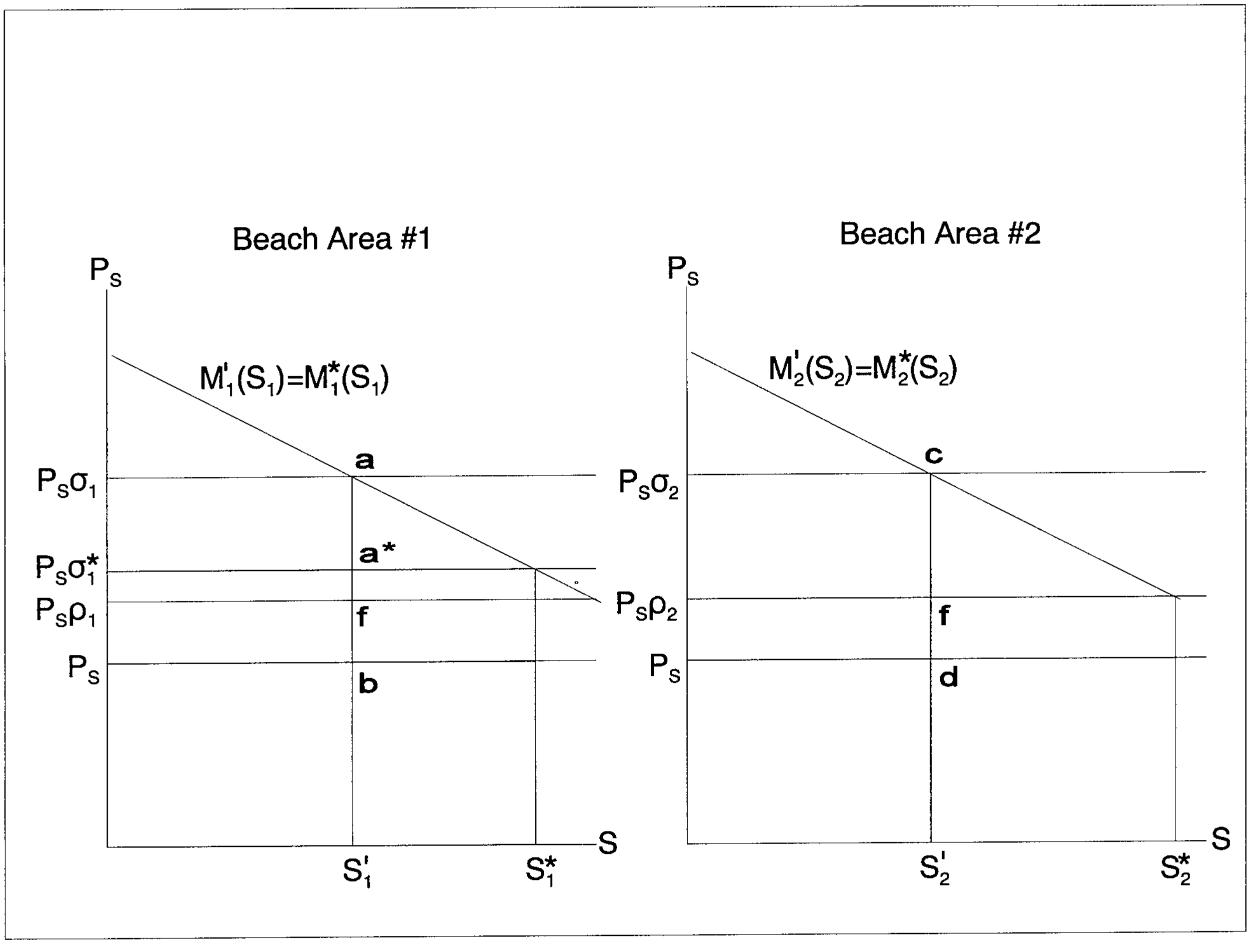


Figure 10 - Induced Development with Subsidized Insurance When Demand for Beach Services is Perfectly Elastic

In this case, the economic effects of development induced by shore protection will depend on whether such further development is additional or relocated development. Shore protection projects that cause a shift of development from nonbeach to beach areas will increase overall environmental costs associated with beachfront development. If one assumes that such additional development would not impose other types of environmental costs if located elsewhere in the economy, the effect of further development along coastlines would be to increase total environmental costs in the economy. In other words, induced development would impose NED costs rather than benefits.

The implications of induced development that represents a relocation, but not an overall increase in development along coastlines, are ambiguous. It is necessary to know the patterns of such relocation in order to gauge the qualitative and the quantitative effects of shore protection on total environmental costs. When environmental losses saved on relocated structures exceed environmental losses on new structures in the protected beach, induced development that is prompted by shore protection will provide environmental benefits by reducing overall environmental costs of coastline development. This outcome is more likely when shore protection shifts development away from other environmentally sensitive beachfront areas, and when the adverse environmental effects of development at those areas is greater than the adverse environmental effect of further development in the protected area.

APPENDIX II-A - ECONOMIC THEORY AND BEACHFRONT DEVELOPMENT

Basic model of shoreline development and beach demand

This appendix supplements the analysis in Section II by developing a more sophisticated model of the way in which beachfront economic activity responds to shore protection. The analysis supplements the graphical presentation in the text. Some aspects of the market for beach services and beachfront residential development had to be simplified in order to allow for convenient presentation on the graphs. As with all economic theory, many details are omitted (that is what makes it theory). This omission of inessential detail does not change the basic character of the final conclusions. At appropriate points, the effects of adding more detail to the model will be indicated. In general, more detail complicates notation without augmenting understanding of the economic issues.

The basis for beachfront development is a demand for beach services. Beachfront development, primarily residential structures, allows households to consume beach services. The proximity of beachfront development to the beach is important to households and there is more than one location appropriate for consuming beach services. This implies a simple model in which there are alternative beach locations, indexed by the subscript **i**, where beach services may be consumed. Initially assume $\mathbf{i=1,2}$, i.e. that there are two possible beachfront locations. Furthermore, assume that there is an "inland area," which is far enough from the beach so that it cannot suffer storm damage. Generally, capital letters will be used to refer to characteristics of beachfront areas and small letters will be used for the inland area. Thus, the quantity of beach development in the beachfront area of beach #1 will be noted $\mathbf{Q_1}$ and the quantity of beachfront development in the inland area noted $\mathbf{q}$. Similarly, for the second beach area, development is noted as $\mathbf{Q_2}$.

There is a simple linear relation between the quantity of development, the location of the beachfront area and the amount of beach services provided. Specifically, the beachfront area of beach #1 produces $\mathbf{B_1} = \tau_1\mathbf{Q_1}$ services when it has $\mathbf{Q_1}$ units of development, with τ_1 reflecting the relation between development and services at beach #1. The inland area produces $\mathbf{b} = \tau\Phi\mathbf{q}$ services when it has q units of development. Note that $\mathbf{0} < \Phi < \mathbf{1}$ is a discount factor reflecting lack of proximity of the inland area to the beach. Given these conventions, the total supply of beach services from the two areas, $\mathbf{B_T}$, may be written as $\mathbf{B_T} = \mathbf{B_1} + \mathbf{B_2} + \mathbf{b} = \tau_1 \mathbf{Q_1} + \tau_2 \mathbf{Q_2} + \tau\Phi\mathbf{q}$. If beaches 1 and 2 are equally attractive and have the same accessibility to population centers, then $\tau_1 = \tau_2$ and beach development is equally productive at the two beachfront areas and at the two inland areas. It is often useful to impose this type of initial symmetry on the problem.

Beach development is the result of capital investment in either beachfront or inland areas. Following conventions in the literature on real estate, assume that development is produced by applying "structure" inputs, S, (generally capital inputs) to land inputs, L, according to the formula: $\mathbf{Q_1} = \mathbf{A_1 S_1}^{\alpha}\mathbf{L_1}^{\beta}$ in beachfront area 1, $\mathbf{Q_2} = \mathbf{A_2 S_2}^{\alpha}\mathbf{L_2}^{\beta}$ in beachfront area 2, and $\mathbf{q} = \mathbf{as}^{\alpha}\mathbf{l}^{\beta}$ in the inland area. These will be termed production functions for beach development. Again, it is useful to impose initial symmetry on the problem, by assuming that production technology is the same everywhere so that $\mathbf{A_1} = \mathbf{A_2} = \mathbf{a} = \mathbf{A}$. Given that the choice of measurement units for land is arbitrary, assume that all areas have one unit of land so that $\mathbf{L_1} = \mathbf{L_2} = \mathbf{l} = \mathbf{1}$, and the production function simplifies to $\mathbf{Q\,i} = \mathbf{As}_i^{\alpha}$ and $\mathbf{q}=\mathbf{As}^{\alpha}$, where $\mathbf{I} = \mathbf{1}$,

2. Generally the literature on residential real estate suggests that $\mathbf{0.6} < \alpha < \mathbf{0.9}$. The distinctions made in this model setup are important because it is the structure inputs located in beachfront areas, i.e. the inputs $\mathbf{S_1}$ and $\mathbf{S_2}$, which can suffer storm damage.

Land in beachfront and inland areas has a rental price of $\mathbf{R_i}$, $\mathbf{i} = \mathbf{1, 2}$, and $\mathbf{r}$ respectively. Rental prices are determined as part of the model. The supply price of structure inputs depends on the likelihood of storm damage. In inland areas, structure inputs are supplied at a uniform price of $\mathbf{p_s}$ because storm damage probability is zero. In beachfront area $\mathbf{i}$, structure inputs are supplied at a price of $\mathbf{P_{Si}} = \sigma_i \mathbf{p_S}$, where $\sigma_i = \mathbf{1} + \Theta_i$, and Θ_i is the probability that a unit of structure will suffer storm damage in beachfront area i. If unsubsidized insurance is available, it is priced at Θ_i per unit $\mathbf{S}$ and its availability has no effect on input choice.[16] Subsidized insurance would be priced below Θ_i and would effectively reduce $\mathbf{P_{Si}}$ in proportion to the amount of the subsidy.

The demand for beach services depends on the distance between population centers and the beaches, income levels of households, the price of beach services, and the price of substitutes for and complements to beach services. Only one of these factors, the price of beach services, is changed by the process of beach protection. The relation between the price of beach services and the price at which beachfront development is supplied follows directly from the expression for B_T above. Specifically, $\mathbf{P_B} = \mathbf{P_{Qi}}/\tau_i = \mathbf{p_q}/\tau\Phi$, where $\mathbf{P_{Qi}}$ and $\mathbf{p_q}$ are the prices of beachfront development in beachfront and inland locations. Note that this equation implies an equilibrium condition in which the price of beach services is equal at each location. This implicitly assumes that all locations, beachfront and inland, and all beaches are being actively used and that other costs of beach recreation, particularly accessibility to population centers, are equal. As with other initial assumptions in this model setup, these assumptions can be relaxed at the expense of greater notational and mathematical complexity.

It is crucial to understand the relation between changes in $\mathbf{P_B}$ and changes in the quantity of beach services demanded, $\mathbf{B_T}$, because it is through this interaction that the division of induced development into relocated and additional development categories takes place. The general relation between price of beach services and quantity demanded may be written as $\mathbf{B_T} = \Gamma \mathbf{P_B}^{\gamma}$. In this form, the parameter Γ reflects factors such as income, population, prices of other goods, distance to the beach, etc and γ is the price elasticity of beach demand, i.e. the percentage change in beach demand produced by a one percent change in $\mathbf{P_B}$. Over the range of changes in $\mathbf{P_B}$ which are generated by shore protection operations at the scale practiced in the U.S., it is most likely that consequent changes in $\mathbf{B_T}$ are negligible, or that demand for beach services is very inelastic with respect to shore protection activities, implying a value of γ close to zero, leaving $\mathbf{B_T}$ constant and equal to Γ.

Even if the average household's decision to engage in beach recreation is sensitive to the cost of beach vacations, the conclusion that $\mathbf{B_T}$ is very inelastic with respect to changes in $\mathbf{P_B}$ caused by Corps shore protection projects follows from a number of observations. First, total annual expenditure by the Corps

[16] This lack of effect can come about for a number of reasons. First, investors can be risk neutral. Second, storm damage can be a unique risk and hence it is diversified away simply by holding a portfolio of real estate in different beachfront areas.

for shore protection is negligible compared to the level of beachfront economic activity.[17] Second, P_B is a small fraction of the total cost of a beach vacation. The major components of cost are travel and the opportunity cost of time. Consider, for example, the extreme case in which Ocean City, Maryland was the only beach available for recreation. Then, if the $\mathbf{P_{Qoc}}$, the rental price for real estate at Ocean City, rose 10% and, given the lack of alternative locations, $\mathbf{P_B} = \mathbf{P_{oc}/\tau_{oc}}$ rose 10% also, the total cost of a week of beach recreation at Ocean City would rise much less than 10% because real estate cost is a modest fraction of the total cost of a week at Ocean City. Thus, our basic assumption for will be that demand for beach services is very inelastic, i.e. $\mathbf{-0.2} < \gamma \leq \mathbf{0}$, with respect to the changes studied here.

The conclusion that the elasticity of demand for the beach services with respect to changes in the cost of beach structure services is small can be contrasted with the case of inland flood control, where the demand for the product produced on the land, whether agricultural or manufactured items, can generally be assumed to be perfectly elastic. In terms of our beach example, this would imply that $\mathbf{P_B}$ was fixed, and B_T varied substantially. It would then follow that massive closing or opening of some beaches would have no effect on attendance at other beaches. Clearly, the assumption that demand is perfectly elastic is easily seen to be inconsistent with observed patterns of beach attendance. The effects of high price elasticity on the results presented here may be seen by selecting numerically large values for γ (given that $\gamma < \mathbf{0}$, numerically larger values of γ are, in fact, algebraically smaller).

Solving the simple model of beachfront development and beach demand

Solution of the simple model under the initial set of assumptions discussed above requires finding particular solution values for the endogenous variables, including levels and prices of development represented by the $\mathbf{Q_i}$'s, $\mathbf{q}$, $\mathbf{P_{Qi}}$'s, and $\mathbf{p_q}$, the amounts of structural inputs measured by the $\mathbf{S_i}$'s and $\mathbf{s}$, land rents $\mathbf{R_i}$ and $\mathbf{r}$, and prices and quantities of beach services, the $\mathbf{P_{Bi}}$'s, $\mathbf{p_b}$, $\mathbf{B_i}$'s and $\mathbf{b}$. Initial values of these endogenous variables are determined by the various parameters of the model along with initial specification of the demand for beach services. The effects of nourishment of a particular beach, such as beach #1, are generated by noting the effects of changing the σ_1 parameter and also τ_1. Nourishment changes σ_1 by lowering the probability of damage to beachfront structures at beach #1. Most nourishment projects also raise τ_1 by making beach #1 larger and hence less congested than it would ordinarily be. This second effect is less certain and, in some cases, shore protection or nourishment could raise dune barriers which would make beachfront location less attractive compared to inland locations.

Solution to the model is achieved by writing an expression for developer profits at each location and assuming that developers use structure inputs to maximize these profits subject to given prices for inputs and beach services. For example, the expected profit of a developer operating on the beachfront of beach #1 would be:

$$\Pi_1 = \mathbf{P_{Q1}Q_1 - P_{S1}S_1 - R_1 = P_B\tau_1Q_1 - p_S\sigma_1S_1 - R_1}$$

[17] Over the past five years, the total Corps budget for shore protection has only averaged about 40 million dollars per year.

$$\Pi_1 = \mathbf{P_B \tau_1 A S_1^{\alpha} - p_S \sigma_1 S_1 - R_1}$$

Conversely, the expected profit of a developer in the inland area would be:

$$\pi = \mathbf{P_q q - p_S s - r = \Phi \tau P_B q - p_S s - r}$$

$$\pi = \mathbf{\Phi \tau P_B A s^{\alpha} - p_S s - r.}$$

Under the assumption that both structures and beach services are provided by perfectly competitive firms under conditions of easy entry, these expressions for expected economic profit may be set equal to zero and analyzed. A bit of fairly standard manipulation yields the following solutions for levels of structure services, development level, and beach services for these areas:

$$\mathbf{S_1 = (\sigma_1 p_S / A \alpha P_B \tau_1)^{[1/(\alpha - 1)]}} \qquad \mathbf{s = (p_s / A \alpha P_B \tau \Phi)^{[1/(\alpha - 1)]}}$$

$$\mathbf{Q_1 = A(\sigma_1 p_S / A \alpha P_B \tau_1)^{[\alpha/(\alpha - 1)]}} \qquad \mathbf{q = A(p_s / A \alpha P_B \tau \Phi)^{[\alpha/(\alpha - 1)]}}$$

$$\mathbf{B_1 = A \tau_1 (\sigma_1 p_S / A \alpha P_B \tau_1)^{[\alpha/(\alpha - 1)]}} \qquad \mathbf{b = A \tau \Phi (p_s / A \alpha P_B \tau \Phi)^{[\alpha/(\alpha - 1)]}}$$

These can be thought of as demand for structure inputs and supply of development and beach service relations appropriate for each beachfront or inland area. Note that similar relations would characterize beachfront area 2 and the model could easily be extended to accommodate any number of beachfront and inland areas. The supply of structure services is important because structure services are the basis for storm damage. The supply of beach services is crucial in clearing the market for beach recreation. Interpretation of the equations is aided by recalling that $(\alpha - 1) < 0$ so that, in all cases, the effect of $\mathbf{P_B}$ on supply is positive in all cases, i.e. $\mathbf{\partial S_1/\partial P_B, \partial Q_1/\partial P_B, \partial B_1/\partial P_B, \partial s/\partial P_B, \partial q/\partial P_B, \partial b/\partial P_B > 0}$.

The model is solved for an equilibrium condition of supply and demand by setting the supply of beach services, the sum of the B_i's and b, expressed as a function of $\mathbf{P_B}$, equal to the demand for beach services, $\mathbf{B_T = \Gamma P_B^{\gamma}}$. Specifically, the initial model setup implies that $\mathbf{B_T = B_1 + B_2 + b = \tau_1 Q_1 + \tau_2 Q_2 + \tau \Phi q}$. Substituting for $\mathbf{B_i}$ and **b** in this relation and setting the result equal to $\mathbf{\Gamma P_B^{\gamma}}$, yields the following so called reduced form equation for $\mathbf{P_B}$:

$$\mathbf{P_B = \{\Sigma_i (A \tau_i / \Gamma)^{(\alpha - 1)/(\alpha + \gamma\alpha - \gamma)}\}\{(q_i p_S / A \alpha \tau_i)^{\alpha/(\alpha + \gamma\alpha - \gamma)} + \Phi^{(\alpha - 1)/(\alpha + \gamma\alpha - \gamma)} (p_S / A \alpha \tau \Phi)^{\alpha/(\alpha + \gamma)} \alpha - \gamma)\},}$$

where it is virtually certain that $\mathbf{(\alpha - 1)/(\alpha + \gamma\alpha - \gamma) < 0}$ **and** $\mathbf{\alpha/(\alpha + \gamma\alpha - \gamma) > 0}$. This relation allows us to calculate the effect of changes in any parameters of the model on $\mathbf{P_B}$ and this change in $\mathbf{P_B}$ along with the change in the supply equations above determines the overall change in beachfront development due to the initial parameter change.

The equation for $\mathbf{P_B}$ along with the input demand and development and beach service supply functions above can be used to deduce the effects of shore protection projects in a more formal and precise fashion than could shown on the graphs in Section II. For example, a shore protection project in beach area 1 should lower σ_1 but leave all other parameters of the model unchanged. The total effect on the $\mathbf{B_i}$**'s, b,**

Q_i's, **q**, S_i's and **s**, can be determined by noting that $\mathbf{dX_j/d\sigma_i} = \partial X_j/\partial\sigma_i + (\partial X_j/\partial \mathbf{P_B})(\mathbf{dP_B/d\sigma_i})$, where $\mathbf{X_j}$ could be any one of the variables in which we are interested. Note that the total change in any variable, $\mathbf{dX_j/d\sigma_i}$, can be broken up into what could be termed a "direct effect," $\partial \mathbf{X}_j/\partial\sigma_i$, and an "indirect effect" due to any change in market price of beach services caused by the direct effect, $(\partial X_j/\partial \mathbf{P_B})(\mathbf{dP_B/d\sigma_i})$. Now note from the equation for $\mathbf{P_B}$ that we can sign $(\mathbf{dP_B/d\sigma_i}) > \mathbf{0}$, i.e. a fall in σ_i lowers $\mathbf{P_B}$ given that $\alpha/(\alpha + \gamma\alpha - \gamma) > \mathbf{0}$, the exponent of σ_i in the reduced form $\mathbf{P_B}$ equation. Now consider the effect of the fall in σ_1 on beachfront area 2 and the inland area. In both cases $\partial \mathbf{B_2}/\partial\sigma_1 = \partial \mathbf{b}/\partial\sigma_1 = \partial \mathbf{Q_2}/\partial\sigma_1 = \partial \mathbf{q}/\partial\sigma_1 = \partial \mathbf{S_2}/\partial\sigma_1 = \partial \mathbf{s}/\partial\sigma_1 = \mathbf{0}$ and there is no "direct effect" of the fall in σ_1 on these areas. But there is an indirect effect because $\partial \mathbf{B_2}/\partial \mathbf{P_B}$, $\partial \mathbf{b}/\partial \mathbf{P_B}$, $\partial \mathbf{Q_2}/\partial \mathbf{P_B}$, $\partial \mathbf{q}/\partial \mathbf{P_B}$, $\partial \mathbf{S_2}/\partial \mathbf{P_B}$, $\partial \mathbf{s}/\partial \mathbf{P_B}$ **are all** $< \mathbf{0}$. Given that $\mathbf{dP_B/d\sigma_1} > \mathbf{0}$, it follows that $\mathbf{dB_2/d\sigma_1}$, $\mathbf{db/d\sigma_1}$, $\mathbf{dQ_2/d\sigma_1}$, $\mathbf{dq/d\sigma_1}$, $\mathbf{dS_2/d\sigma_1}$, $\mathbf{ds/d\sigma_1}$ **are all** $< \mathbf{0}$. These are, of course, the results shown in the graphical analysis.

In the case of beach 1, it is easily seen that $\partial \mathbf{B_1}/\partial\sigma_1$, $\partial \mathbf{Q_1}/\partial\sigma_1$, $\partial \mathbf{S_1}/\partial\sigma_1$ are all negative and hence the direct effect of the fall in σ_1 is to raise $\mathbf{B_1}$, $\mathbf{Q_1}$, and $\mathbf{S_1}$. In contrast, the indirect effect of the fall in $\mathbf{P_B}$, given $\mathbf{dP_B/d\sigma_1} > \mathbf{0}$, **and** $\partial \mathbf{B_1}/\partial \mathbf{P_B}$, $\partial \mathbf{Q_1}/\partial \mathbf{P_B}$, $\partial \mathbf{S_1}/\partial \mathbf{P_B}$ are all positive, is negative. Nevertheless, we know that the direct effect must be larger than the indirect effect because the fall in $\mathbf{P_B}$ in the reduced form requires a rise in $\mathbf{B_T}$ which must come from beach 1 given that production elsewhere is known to fall. Thus, we conclude that $\mathbf{dB_1/d\sigma_1}$, $\mathbf{dQ_1/d\sigma_1}$, $\mathbf{dS_1/d\sigma_1}$ are all negative and that a fall in σ_1 due to a shore protection project in beach area 1 will raise output of beach services, induce development, and expand structure inputs in beach area 1 as shown in the graphical analysis. Relocated development from beach area 2 and the inland area, i.e. the contraction in these areas in response to the fall in σ_1, plays a significant part in generating the induced development at beach area 1. Given estimates for the various parameters of the elaborated theoretical model presented here, the precise nature of these qualitative responses shore protection could be determined.

SECTION III
SURVEY OF BEACHFRONT COMMUNITY RESIDENTS

INTRODUCTION

The theory in Section II demonstrates how induced development at a protected beach can occur when a Corps project lowers expectations of future storm damage problems. This suggests that the mere approval of an area for study or future protection could induce development if there is a perception of a Corps guarantee against future damage. This section reports the results of a survey conducted in beachfront communities facing significant erosion problems. The survey is designed to answer a number of questions about the perceptions of homeowners in these areas. Do property owners perceive the danger of economic losses from storm damage? Are they aware of the role played by shore protection activities of the Corps in mitigating these losses? Do they perceive a Corps guarantee of protection? How does the presence of an active Corps project influence their perceptions of the role of the Corps in providing protection? Do all homeowners have similar perceptions or are their differences based on their personal characteristics?

To answer these questions about resident perceptions, a survey was conducted in beachfront communities where erosion and/or flood damage threats were significant. The areas in which the survey was conducted were selected to form a natural experiment in which the level of Corps activity varied systematically from zero to substantial. The results, which are first tabulated and then analyzed statistically in this section, allow some inferences to be drawn about whether residents are aware of storm and/or erosion hazards, as well programs such as insurance, that spread the risk of loss from such hazards, and Corps shore protection projects that mitigate such risks. But the most important inferences to be made based on the survey concern the factors which cause homeowners to perceive the Corps as an actual or potential solution to problems of erosion or flooding. Tests are conducted to determine if the presence of Corps activity in an area is perceived as providing a guarantee, real or implicit, against future damage. The perception that Corps activity provides a guarantee against hazards could lower expected future damages in the fashion illustrated in the previous theory section. If Corps activity in an area results in such perceptions, then it could produce significant amounts of induced development. Conversely, failure of homeowners to view the presence of Corps projects as providing significant relief from shore and/or erosion hazards would indicate that the Corps has only a small effect on expected losses and, hence, induced development effects are small.

As is the case with all surveys, some caution must be exercised in interpreting these results. Survey respondents were necessarily told that the survey was being conducted by the Corps, which, almost inevitably, should have drawn attention to the agency. This *Corps identification bias* could have two effects on their answers. First, the knowledge that respondents were speaking to a representative of the Corps should make them more aware of the role of the Corps in shore protection. Second, some respondents could behave strategically and overstate their concerns about beach erosion in order to give the impression that Corps projects were needed. Surveying owners of beachfront property could also introduce *selection bias* because ownership of such property could affect attitudes toward erosion and flooding hazards. Other things being equal, individuals purchasing and continuing to own beachfront real estate are likely to be less concerned about flooding and erosion than similar individuals who are not willing to purchase such property. Given that perceptions of risk vary, those who hold risky assets are likely to have lower estimates of the likelihood of loss than those who do not hold such assets. Finally, there is always a problem of *response bias* which arises because individuals most concerned with an issue are most likely to take the time to respond to a survey. Fortunately, however, the likely direction of each of these individual sources of bias can be anticipated and taken into account, both in designing the survey and in interpreting its results.

SURVEY DESIGN AND IMPLEMENTATION

Questions on the survey document were taken from those approved for form OMB 0710-0001 with minor editing to suit the group being questioned. A copy of the survey document is included as Appendix III-A to this section. The categories of information solicited included characteristics of the property and attitudes of the homeowner. Specific attitudes included: awareness of flood and erosion risk, importance of insurance, and perception of public sector efforts at protection. The survey design and implementation were chosen to reveal information about respondent perceptions and knowledge and attempting to eliminate Corps identification bias, selection bias, and response bias.

Area Surveyed

In order to elicit responses from property owners who had a range of different experiences with Corps beach projects, the survey was administered in three different types of beachfront areas. One area was made up of adjacent beachfront communities in which problems of erosion had caused the Corps to become active in one, but not all, of the communities. The area selected includes southern Duval County, Florida (Jacksonville, Atlantic, and Neptune beaches) that had protection projects and northern St. Johns County (Ponte Vedra), where the Corps has not been active. The survey was also administered in an area where two adjacent beaches both have had Corps projects. This area is near Wilmington, North Carolina, and includes two beach areas, Carolina Beach and Wrightsville Beach. Carolina Beach has had a protection project to control serious erosion problems and Wrightsville Beach has had both a general nourishment project to control erosion and some jetty construction. These projects have resulted in the creation of additional land suitable for development. Finally, the survey was administered in an area with adjacent beaches that have had no Corps projects. This third group of adjacent beaches was in New Jersey in the Manasquan area where erosion problems had received considerable attention and were even the object of a recent paper in the academic literature.[18] The Corps has not been active in these areas but there are proposals for such activity. Thus, the sample was selected to elicit responses from property owners in beachfront areas with different ranges of Corps beach protection and nourishment activities: an area of adjacent beachfront communities with Corps projects at each beach; an area of adjacent beachfront communities with Corps activity at some but not all beaches; and an area of adjacent beachfront communities with no Corps projects at any beach.

The specific areas selected for sampling were the first and second row of beachfront residential single family housing in the three areas. Housing units were surveyed consecutively. No attempt was made to stratify the sample by type of housing unit or by demographic characteristics of the occupant. Instead, the sample was stratified in order to produce approximately equal numbers of observations from three areas:

[18] The area surveyed is immediately south of the site of a Corps project that is just beginning. As noted by Silberman, Gerlowski, and Williams (1992), there has been significant publicity about potential erosion problems in New Jersey.

Manasquan where there was no Corps activity; Duval-St Johns Counties where the Corps was active in half the area; and, Carolina-Wrightsville Beach where Corps activity has been substantial throughout the area. Thus, the experimental structure of the sampling frame is designed to allow observation of the relation between different levels of Corps "treatment" and differences in public perceptions of the role of the Corps in providing shore protection. Sufficient time was allocated to the survey so that approximately equal sample sizes were obtained from each area.

Administering the Survey

In order to minimize response bias, attempts were made to get a high response rate by making the cost of responding as low as possible. First, the questionnaire was administered by enumerators who went door-to-door along the first and second row of housing in beachfront areas. Second, the questionnaire was short, so that it could be administered in about ten minutes. Third, the questions did not require factual responses which would necessitate searching records. Only responses from property owners were accepted because renters have little role in determining induced development. Lastly, individuals who were willing to respond were given the option of filling out the survey at a later time and mailing it in. The idea being that those who wished to fill out the survey with the enumerator, but could not, due to time constraints or other factors, could do so when convenient for them, and thereby increase the sample. In the administration of the survey in the Florida beaches, 89 contacts were made at households. Of these, 37 ultimately responded, of which 30 were homeowners. In New Jersey, 45 contacts were made at households, 41 responded, and 27 of these were homeowners. In North Carolina, 92 household contacts were made, 42 were willing to respond, and 32 of these were homeowners. Differences in the willingness to respond can be attributed to differences in the quality of the weather and other uncontrollable factors concerning the time and location of survey enumeration.

Survey Questions

A copy of the questionnaire used for the survey is included as Appendix III-A at the end of this section. Questions were adapted from those approved for use by the Office of Management and Budget, OMB 0710-0001. The categories of information solicited include: characteristics of the housing unit including proximity to the coastline; participation in the National Flood Insurance Program and concerns about insurance; perceptions of possible damage to the housing unit and to the local beach; rents that could be generated by the unit; and expectations regarding the present and future role of public agencies, including the Corps, in mitigating damage threats to beaches and beachfront property.

Questions regarding the role of public agencies were placed at the end of the questionnaire and included an opportunity for open-ended responses to give maximum latitude for respondents to relate the problems identified in the earlier questions to possible public sector solutions. Three different approaches to this issue were taken, each with its own set of questions. First, respondents were asked if the local beach was threatened and why they felt that the threat did or did not exist. The Corps could be mentioned either as a reason for lack of concern or as a possible source of relief from the threat. This response indicates the perception of a *general role* for the Corps. Second, there was a general question about the role of public agencies in which respondents were asked to record all names of agencies perceived to have taken actions to reduce any problems. This question is asking about the *specific role* of the Corps. The third approach in the questions asks about activity of local agencies. Given that cost sharing is required for Corps projects, it is possible that individuals attribute Corps activities to local agencies. The response to this question allows determination of any *indirect role* for the Corps acting through local agencies.

Questions about Corps involvement were placed at the end of the questionnaire in order to reduce the problem of Corps identification bias noted earlier. Because the Corps is identified at the start of the survey by a cover letter and the survey enumerating announces that the Corps is sponsoring the survey, respondents are likely to have the Corps firmly in mind as they begin to respond to the survey, which would tend to magnify the effects of Corps identification bias. Placing specific questions about the Corps at the end of the survey should reduce, although not eliminate, the tendency to mention the Corps in connection with beach problems simply because the survey is identified with the Corps.

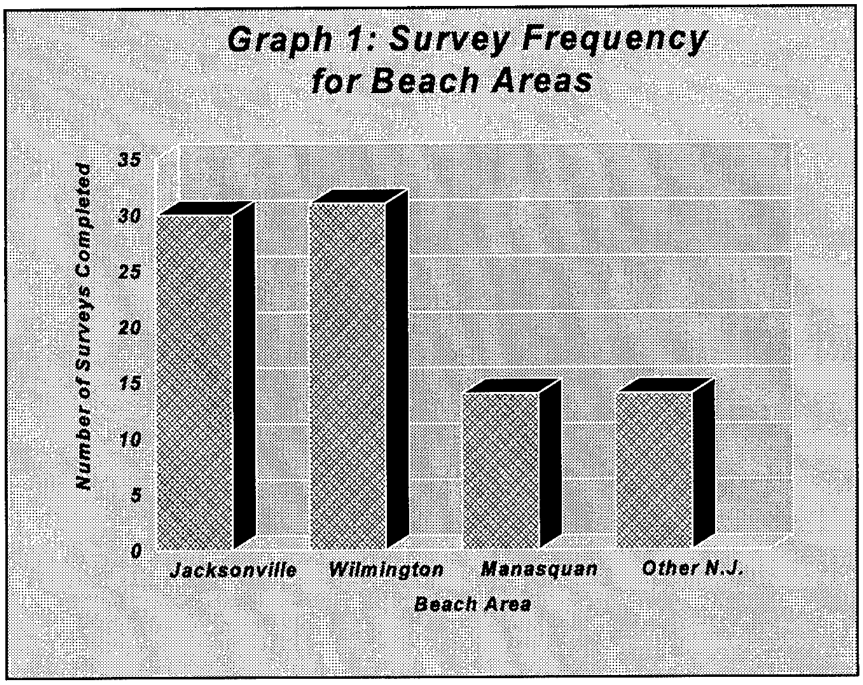
DESCRIPTIVE TABULATIONS OF THE RESPONSES

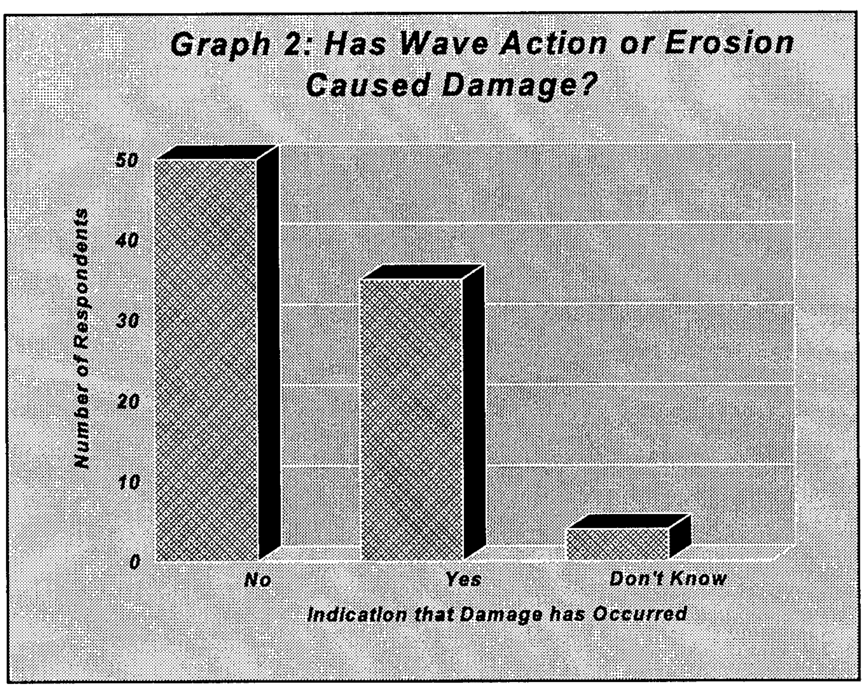
Basic characteristics of the areas surveyed and the perceptions of respondents are described by simple tabulations of the responses. Cross tabulations are not a substitute for formal statistical hypothesis testing but they help to characterize the nature of the areas being surveyed and to document the concern of the residential population with problems of storm damage and erosion. A formal statistical analysis of fundamental questions concerning the factors which cause respondents to regard the Corps as a potential solution to problems related to flooding or erosion will follow in the next subsection.

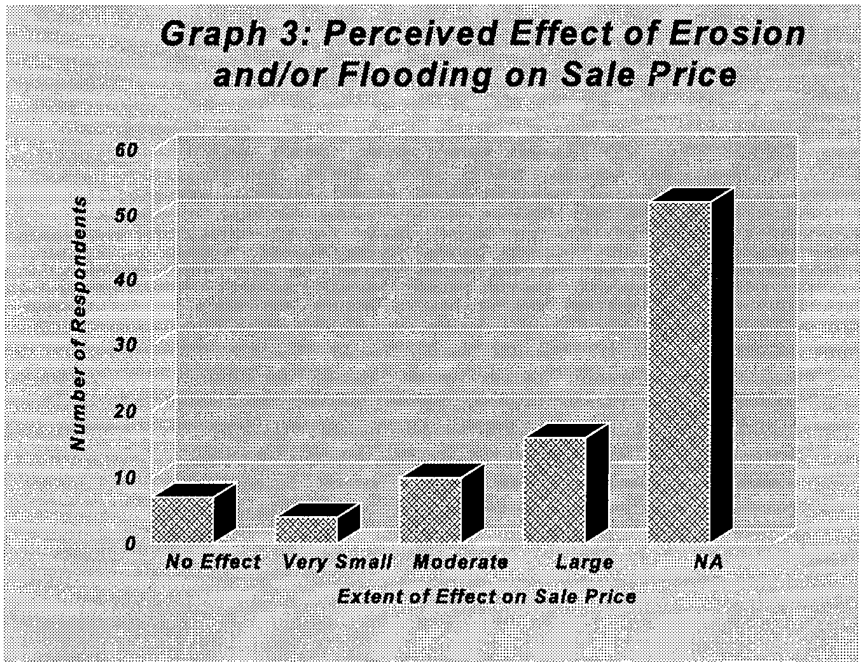
A total of eighty-nine surveys were completed.[19] Graph 1 shows that these surveys were divided almost equally between the Florida, North Carolina, and New Jersey beachfront areas. Beach erosion is a significant problem in these areas. Graph 2 shows that thirty-five of the eighty-nine respondents had observed erosion damage to either their own property or nearby property and Graph 3 shows that over one-fourth of the respondents felt that this erosion had a moderate or large effect on the sales price of their own house. As indicated by Graph 4, the vast majority of households, over 70% of those surveyed and over 80% of those who responded to the question, participated in the National Flood Insurance program. All these results suggest high levels of concern with erosion or storm damage.

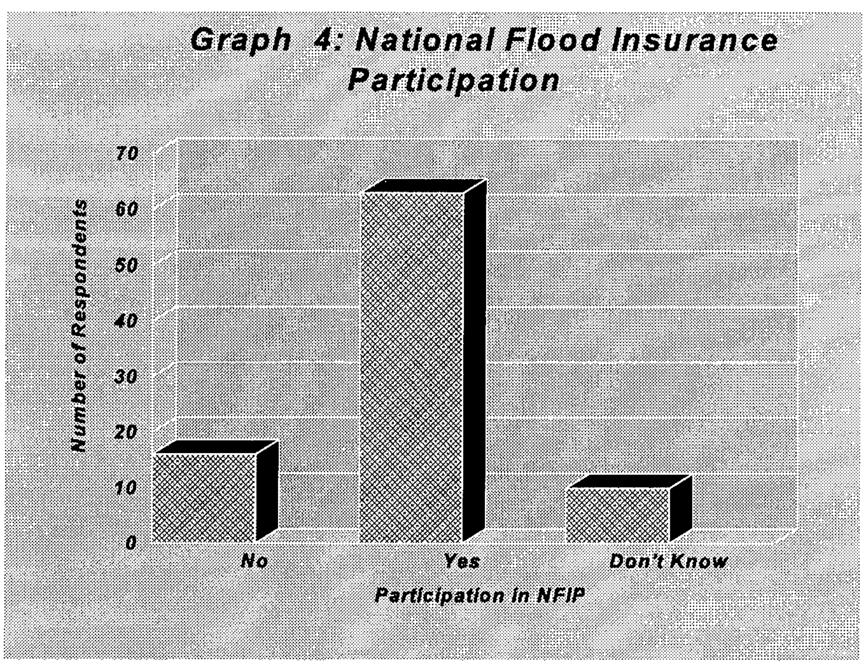
Now consider the perception of the Corps as indicated by the three sets of questions dealing with the problem of local beach erosion. Graph 5 shows the pattern of responses to the question designed to reveal the *general role* of the Corps in relation to local storm damage or erosion problems. Public agencies were clearly not mentioned often and the Corps was mentioned in less than 10% of the cases surveyed. Graph 6

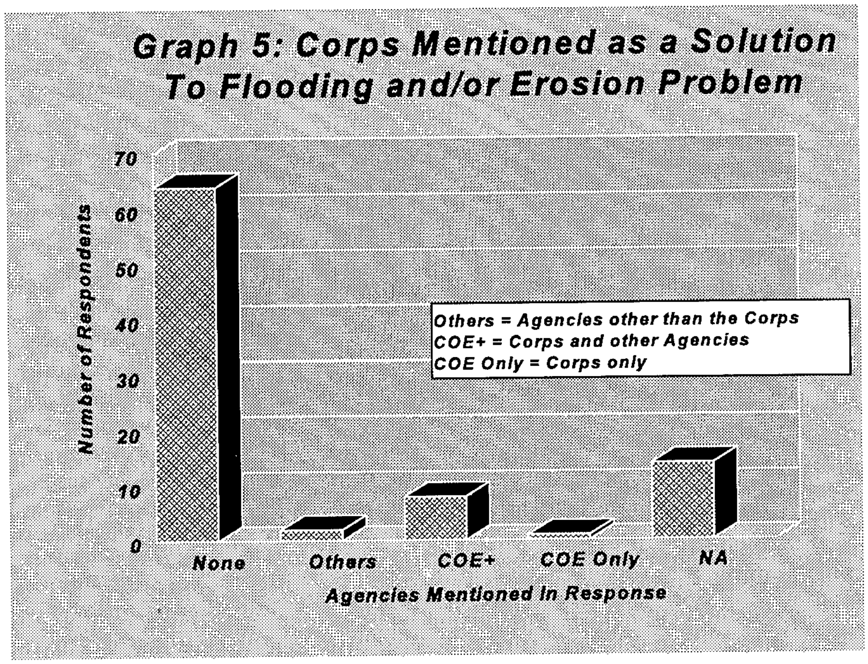
[19] Approximately seventy of the surveys were completed by the survey takers who recorded the responses of the households. If households were unwilling to be surveyed at the time, the survey was left with a stamped return envelope and they were asked to respond promptly. Mail responses which were received in a timely fashion were added to the data set. Most of these mailed responses came from Florida. Apparently, the excellent beach weather in Florida on the days of the survey made households less willing to respond to the questions immediately. The excellent weather and desire to get to the beach quickly may also account for the lower response rate from Florida and, to a lesser extent, from North Carolina. Put another way, the high response rate from New Jersey may reflect the cloudy, cool weather at the time of the survey in that area.

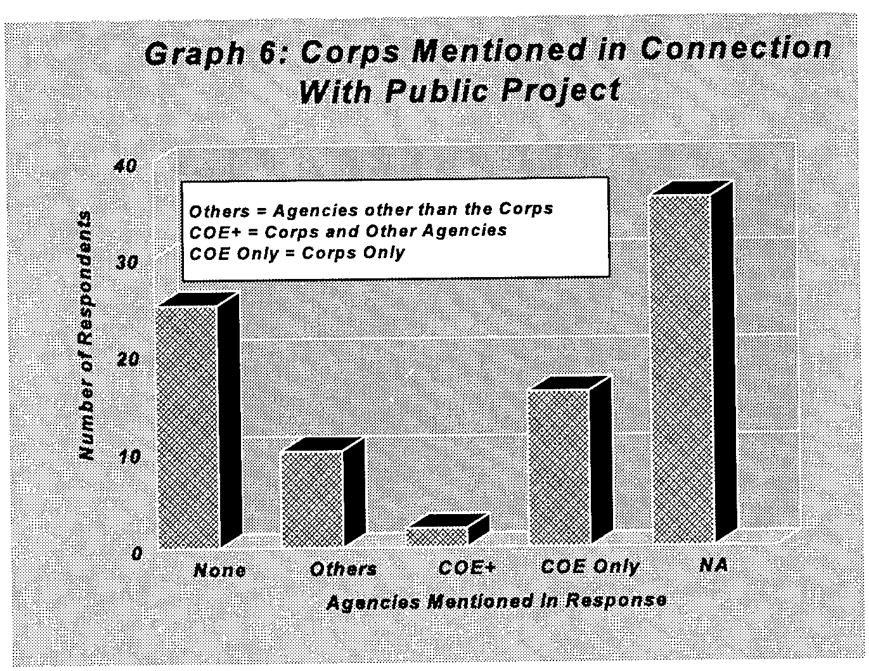

Graph 1: Survey Frequency for Beach Areas
Number of Surveys Completed
35
30
25
20
15
10
5
0
Jacksonville
Wilmington
Manasquan
Other N.J.
Beach Area


Graph 2: Has Wave Action or Erosion Caused Damage?
Number of Respondents
50
40
30
20
10
0
No
Yes
Don't Know
Indication that Damage has Occurred


Graph 3: Perceived Effect of Erosion and/or Flooding on Sale Price
Number of Respondents
60
50
40
30
20
10
0
No Effect
Very Small
Moderate
Large
NA
Extent of Effect on Sale Price


Graph 4: National Flood Insurance Participation
Number of Respondents
70
60
50
40
30
20
10
0
No
Yes
Don't Know
Participation in NFIP


Graph 5: Corps Mentioned as a Solution To Flooding and/or Erosion Problem
Number of Respondents
0
10
20
30
40
50
60
70
Others = Agencies other than the Corps
COE+ = Corps and other Agencies
COE Only = Corps only
None
Others
COE+
COE Only
NA
Agencies Mentioned in Response


Graph 6: Corps Mentioned in Connection With Public Project
Number of Respondents
0
10
20
30
40
Others = Agencies other than the Corps
COE+ = Corps and Other Agencies
COE Only = Corps Only
None
Others
COE+
COE Only
NA
Agencies Mentioned in Response

indicates that when responses regarding the *specific role* of the Corps were elicited, the Corps became more prominent. Over 20% of the respondents mentioned the Corps and it was clearly more important than other public agencies. The third set of questions was designed to determine an *indirect role* of the Corps in connection with community efforts resulted in the pattern of responses displayed in Graph 7.[20] While the Corps is mentioned by only 10% of those surveyed, this exceeds the rate at which specific local agencies are identified.

It is tempting to conclude from Graphs 5-7 that the Corps is perceived as being far more important than local agencies in dealing with storm damage or beach erosion problems. However, these results could be due to Corps response bias which causes recollection of the Corps to crowd out other entities. Indeed, given the likely presence of Corps response bias, it is surprising that the rate at which the Corps is mentioned in response to separate questions on the general, specific, and indirect role is not higher. This suggests that the perceived connection between Corps activities and coastal flooding or beach erosion problems is not strong.

Some simple cross-tabulations allow the sample to be disaggregated so that the relation between household characteristics and perception of storm damage or beach erosion problems and the Corps can be examined. Years of residence is an obvious factor influencing such perceptions. Less obvious, but potentially important given requirements for Corps projects, is the influence of income. Because Corps projects require provision for public access, it is possible that more affluent, exclusive communities find them less attractive. Although the survey did not ask about income directly, number of bedrooms in the house provides a reasonable proxy variable for income and/or wealth.[21]

Graphs 8 and 9 show the relation between time of homeownership in years and the perceived threat of flood damage to real estate or erosion damage to the local beach. Overall it appears that more recent owners are slightly more likely to feel threatened by flooding or erosion problems. The econometric analysis which follows will determine if the relation between years of ownership and perceived threat is statistically significant. Graph 10 shows that the probability of mentioning the Corps, in response to any of the three questions on its role, increases with time of ownership. This could indicate that coastal flooding or beach erosion problems are more apparent than the Corps.

Graphs 11 and 12 indicate that there is no relation between income or wealth, as proxied by number of bedrooms, and perception of a threat to real estate or beaches.[22] Graph 13 shows that participation in National Flood Insurance is also unrelated to number of bedrooms, although there is a $250,000 limit on

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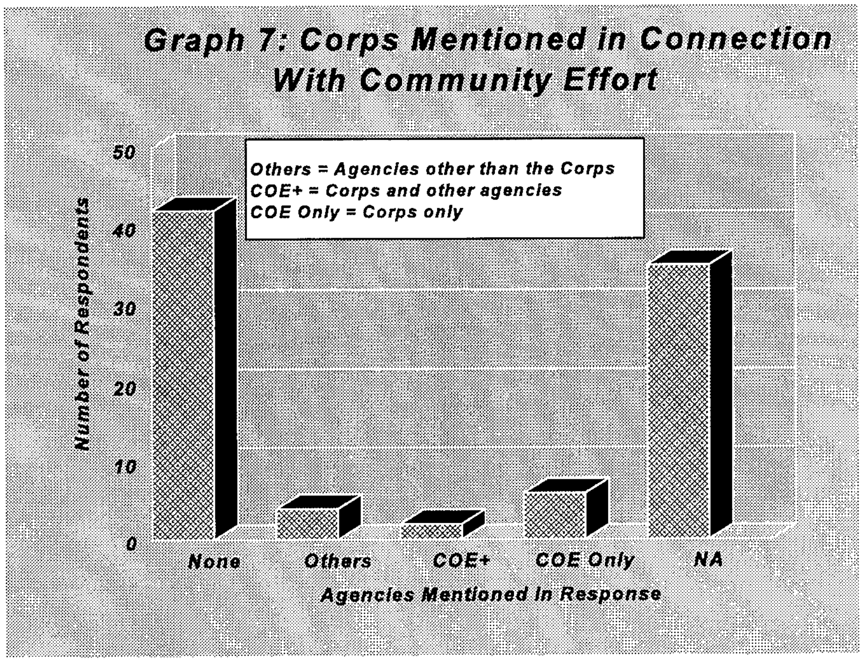
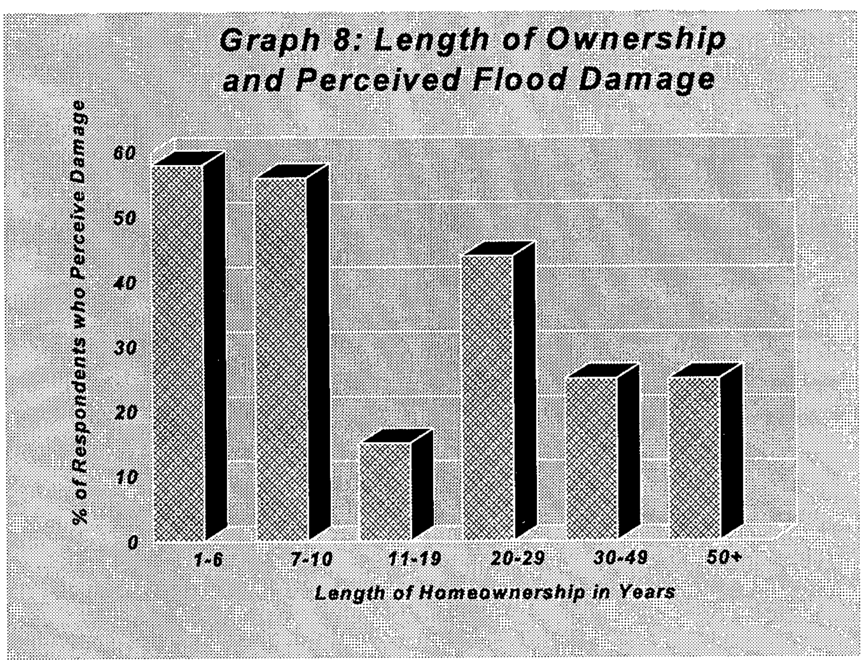
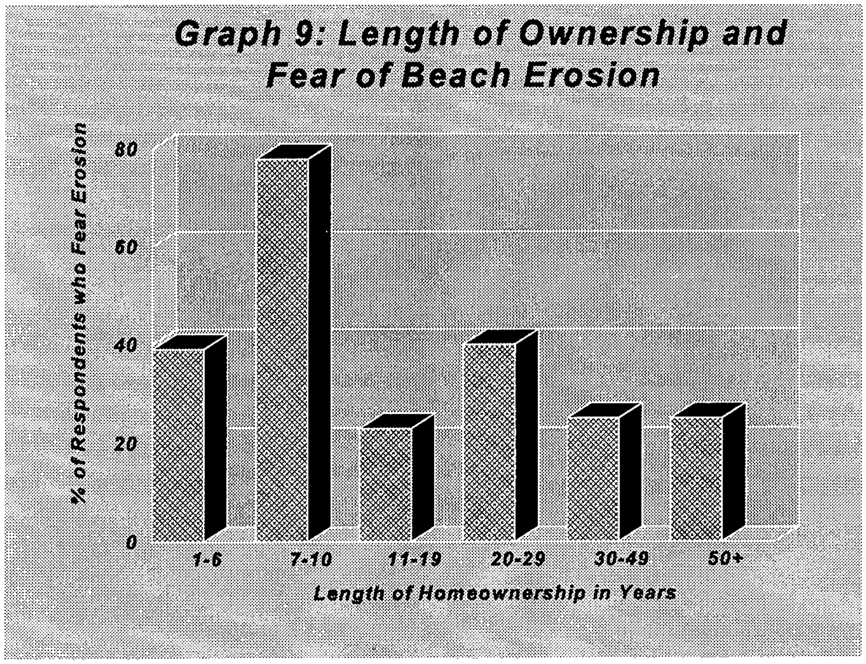
[20] The questions used to elicit information about household perception of Corps activity in the area were numbers 17, 18, and 19 (see copy of questionnaire in Appendix III-A).

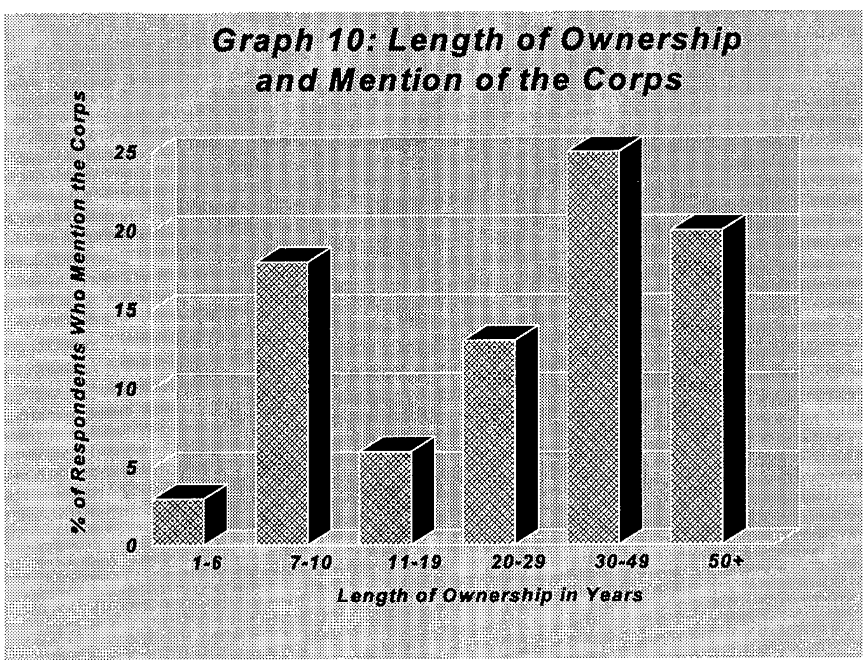
[21] Given that many respondents are reluctant to provide reliable information about their economic status, no direct questions on income or wealth were included. Number of bedrooms provides an adequate proxy variable.

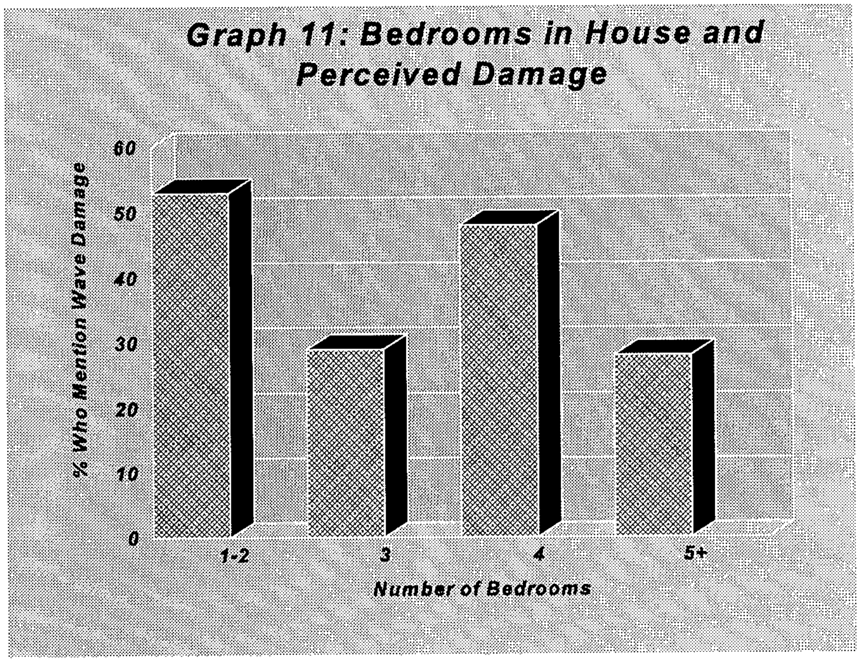
[22] Question 10 on the questionnaire shown in Appendix III-A was used to determine if there was a perception of a threat to the local beach.

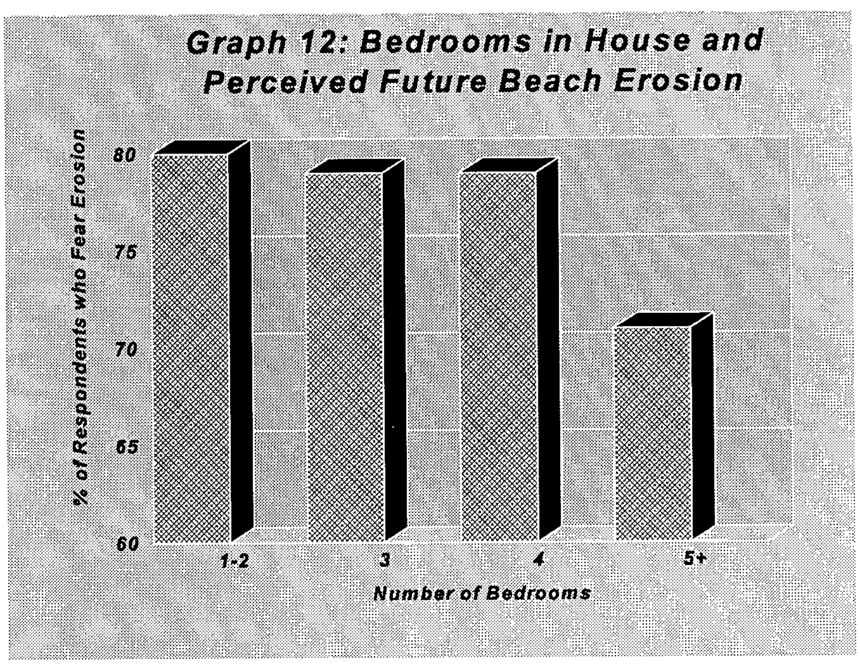

Graph 7: Corps Mentioned in Connection With Community Effort
Others = Agencies other than the Corps
COE+ = Corps and other agencies
COE Only = Corps only
Number of Respondents
0
10
20
30
40
50
None
Others
COE+
COE Only
NA
Agencies Mentioned in Response

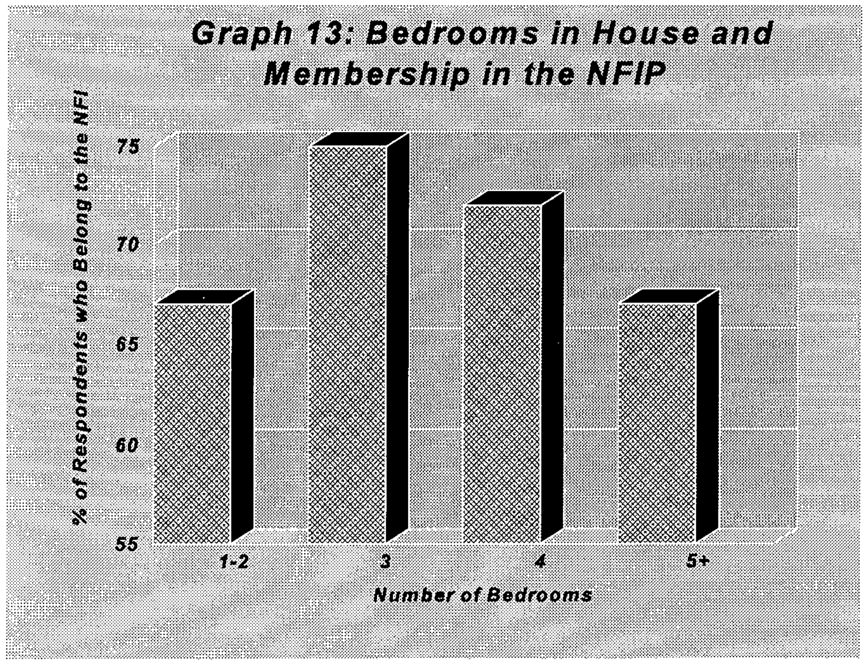

Graph 8: Length of Ownership and Perceived Flood Damage
% of Respondents who Perceive Damage
0
10
20
30
40
50
60
1-6
7-10
11-19
20-29
30-49
50+
Length of Homeownership in Years

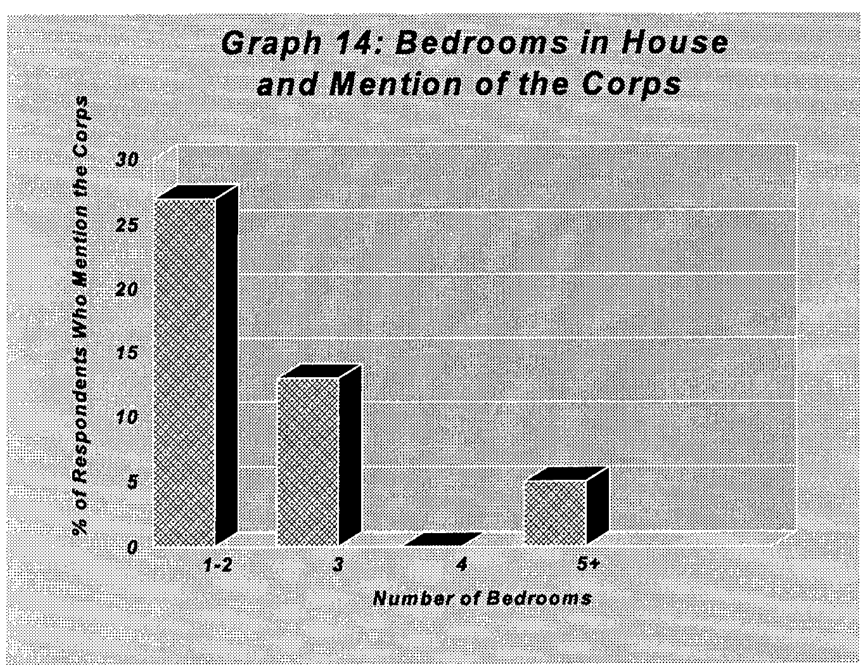

Graph 9: Length of Ownership and Fear of Beach Erosion
% of Respondents who Fear Erosion
0
20
40
60
80
1-6
7-10
11-19
20-29
30-49
50+
Length of Homeownership in Years


Graph 10: Length of Ownership and Mention of the Corps
% of Respondents Who Mention the Corps
0
5
10
15
20
25
1-6
7-10
11-19
20-29
30-49
50+
Length of Ownership in Years


Graph 11: Bedrooms in House and Perceived Damage
% Who Mention Wave Damage
0
10
20
30
40
50
60
1-2
3
4
5+
Number of Bedrooms


Graph 12: Bedrooms in House and Perceived Future Beach Erosion
% of Respondents who Fear Erosion
60
65
70
75
80
1-2
3
4
5+
Number of Bedrooms


Graph 13: Bedrooms in House and Membership in the NFIP
% of Respondents who Belong to the NFI
75
70
65
60
55
1-2
3
4
5+
Number of Bedrooms


Graph 14: Bedrooms in House and Mention of the Corps
% of Respondents Who Mention the Corps
30
25
20
15
10
5
0
1-2
3
4
5+
Number of Bedrooms

insurance coverage. However, Graph 14 reveals an inverse relation between the proportion of respondents mentioning the Corps and the number of bedrooms. This is consistent with the hypothesis that high income areas find Corps protection less attractive because, in order to obtain Corps protection, areas are generally required to provide significant levels of public beach access.

STATISTICAL ANALYSIS OF THE SURVEY RESULTS

Based on the descriptive tabulations presented above, it appears that the residents surveyed have observed significant levels of damage and regard erosion as a threat. Also, it is evident that the Corps is not widely regarded as a solution to these problems. However, the fundamental question concerns the factors which are associated with a positive perception of the Corps as a solution to problems of flooding or erosion. A formal answer to this question requires statistical analysis of the survey data to determine the relation between respondent characteristics and perception of the Corps. The test relies on the natural experiment implicit in the structure of the sample across a range or areas experiencing different levels of Corps shore protection activity.

The likelihood of assigning a general, specific, or indirect role to the Corps appears to depend on income or wealth as proxied by number of bedrooms, and knowledge of flooding and erosion problems as proxied by length of ownership. In addition, it is at least plausible that perceived storm damage or threat of erosion or participation in the National Flood Insurance program could contribute to recognition of the Corps. Most important is the possibility that location in an area which is being actively nourished by a Corps project could influence perceptions. If the presence of Corps activity is perceived as a sign or guarantee that future damage expectations can be revised downward, then the theory in Section II suggests that induced development effects may be large. The sample was intentionally selected to include areas with different levels of Corps shore protection project activity to allow testing of the effects of the presence of a project on perceptions of the role of the Corps in providing protection. Finally, location in Florida or North Carolina as opposed to New Jersey could be important. It is possible to determine if any or all of these factors has a significant influence on responses to the questions about the role of the Corps by estimating the parameters of the following equation:

$$\mathbf{Role_i} = \alpha_0 + \alpha_B\,\mathbf{Bedrooms} + \alpha_T\mathbf{Time} + \alpha_D\mathbf{Damage} + \alpha_T\mathbf{Threat} + \alpha_{NFI}\,\mathbf{NFI} + \alpha_A\,\mathbf{Active} + \alpha_F\,\mathbf{Florida} + \alpha_{NC}\,\mathbf{NC}$$

where: **Role$_i$ is a 0-1 dummy variable indicating whether the respondent identified the Corps in relation to specific role type i, general, specific, indirect;**

Bedrooms is the number of bedrooms in the unit;

Time is years of ownership;

Damage is a 0-1 dummy variable indicating perception of damage;

Threat is a 0-1 dummy variable indicating a perceived threat to the local beach;

NFI is a dummy variable equal to 1 if the household indicates that it participates in the National Flood Insurance program;

Active is a dummy variable equal to 1 if the Corps has an active shore protection project in the area and 0 otherwise;

Florida and NC are dummy variables equal to 1 if the observed beach is in Florida or North Carolina respectively and 0 otherwise, and the α's are parameters to be estimated.[23]

The equation for $Role_i$ is estimated using maximum likelihood logit techniques with the results presented in Table 1 below. In addition to estimating separate equations for each of the three roles, combined equations were also estimated in which the dependent variable was set to unity if the Corps was mentioned in connection with any combination of the two or three roles.[24]

The estimation results are displayed in Table 1. Overall, these estimates yield rather simple and statistically robust conclusions. First, mention of a role for the Corps falls with income and wealth, as proxied by number of bedrooms. Put another way, the estimated coefficient of Bedrooms is generally negative and statistically significant. For example, the estimated coefficient of Bedrooms at the top of Table 1 is -1.08 with a standard error of 0.49 and the probability that the true coefficient is zero is only 3% as indicated in the column which shows Prob $> |t| > 0.03$. Second, perception of a role for the Corps is directly related to length of ownership, i.e. the estimated coefficient of Time is generally positive and statistically significant. These two results are statistically significant and quite stable except for the case in which the indirect role is analyzed by itself. But, in this case, no variable is statistically significant. Third, the perception of actual damage nearby generally is associated with a greater tendency to mention the Corps, i.e. the estimate coefficient of Damage is generally positive and statistically significant. Fourth, the other variables analyzed have no statistically significant effect on the likelihood that the Corps is perceived as having a significant role in preservation or protection of the beach area. Perhaps the most remarkable result is the finding that the presence of an active Corps project at the local beach is not associated with a

[23] The following questions from the questionnaire in Appendix III-A were used as the basis for the variables in the regression estimates. $Role_i$ is based on questions 17, 18, and 19 respectively, Bedrooms is based on question 4, Time comes from question 5, perception of damage near the unit is from question 10, Threat to the local beach comes from responses to question 16, and participation in National Flood Insurance is from question 7. The possible relation between bedrooms and years of residence and a perceived role for the Corps was suggested by Ethan Wade who was in charge of processing the survey data.

[24] It has been suggested that the presence of an active Corps project in an area could also be a cause of lower levels of perceived damage or threat of erosion. It is possible to test this hypothesis statistically by testing the relation between the Damage or Threat variables and the Active variable. This test was performed and no relation was found between the Active dummy variable indicating the presence of a Corps project and damage or threat perceptions. Of course this is not surprising because the areas surveyed were picked based on the presence of significant ongoing erosion problems that will likely require attention in the future.

greater likelihood that residents recognize a role for the Corps. It appears that the Corps has a very low profile indeed. The presence of a Corps project in an area does not raise perceptions that the Corps provides a possible solution to problems of coastal flooding or beach erosion. Furthermore, recent homebuyers appear to be particularly unaware of Corps protection. Given that new homebuyers are particularly important in determining the demand for incremental development, their low rate of perception that the Corps provides a guarantee against or solution to coastal flooding or beach erosion problems suggests that the potential expectations effect discussed in the theory section is not large.

These survey results are consistent with the hypothesis that the Corps has little effect on residential real estate development in beachfront communities. Given the presence of Corps identification bias, the low level of recognition of a role for the Corps in these areas suggests that residents do not perceive the Corps as the sole source of protection. Even when the Corps is active in nourishing the beachfront, awareness of the Corps is not raised significantly. Longer term residents are more aware of the Corps, but these are not the residents who are responsible for induced development. The finding that the proxy for income and wealth is negatively related to perceptions of a role for the Corps is also most interesting. It appears that one role for the Corps is securing and enhancing public access to beach areas. For higher income individuals, this public presence appears to be an intrusion and the role of the Corps in protection activities is correspondingly reduced. It is possible that some relations among variables that are non-significant given the small sample size available for this study would be significant in a larger, more elaborate study. However, even with a modest sample size, this study was able to isolate a number of highly significant statistical relations that give a clear indication of the way in which households perceive threats to their beachfront communities and the role of the Corps.

At the same time that the household survey described here was being conducted, an informal attempt was made to determine the perceptions of local real estate agents in the Duval and Wrightsville areas where Corps activity has been significant. Local real estate offices in these beachfront communities were visited and agents were asked about the effects of Corps activity on local real estate markets as well as the role of insurance cost in residential real estate development decisions. These interactions with real estate professionals produced a number of insights which appear consistent with the survey results. First, there was a general inability to recognize which areas were authorized for Corps shore protection projects. Second, Corps protection was not regarded as an important factor influencing the pattern of real estate development. Third, flood insurance was regarded as a rather minor expense category which was not important in pricing real estate. Indeed, examination of Multiple Listing Service records for beachfront communities revealed that no information on insurance cost or flood hazards was provided; the fields of the MLS record indicating insurance costs were routinely left blank. It is understanding that real estate agents would not wish to discuss the potential for storm damage or beach erosion with prospective buyers whether the beachfront area was or was not protected by Corps projects. The finding that recent homebuyers in these beachfront communities are generally unaware of the role of the Corps in shore protection may reflect this failure to communicate information about potential storm damage and beach erosion by real estate professionals.

TABLE 1 - FACTORS ASSOCIATED WITH RECOGNIZING THE CORPS (continued)

Dependent Variable = General Role For Corps

Logit Estimates		Number of obs	=	88
		chi2(7)	=	12.37
Log Likelihood = -20.623935		Prob > chi2	=	0.0891

Variable Role 1	Coefficient	Std. Error	t	Prob > |t|	Mean .0909091
Bedrooms	-1.080851*	.4886874	-2.212	0.030	3.863636
Time	.0473434*	.0230152	2.057	.043	16.40523
Active	.6971666	1.027104	0.679	0.499	.6022727
Damage	.7483681	.9576065	0.781	0.437	.3863636
Threat	.6824254	1.289321	0.529	0.598	.7727273
NFI	-.2901419	.9245164	-0.314	0.754	.7045455
Florida	.2562733	.9389172	0.273	0.786	.3409091
Constant	-1.037097	1.991472	-0.521	0.604	1

Dependent Variable = Specific Role For Corps

Logit Estimates		Number of obs	=	88
		chi2(7)	=	17.28
Log Likelihood = -35.942337		Prob > chi2	=	0.0273

Variable Role 1	Coefficient	Std. Error	t	Prob > |t|	Mean .2045455
Bedrooms	-.3936	.2684743	-1.466	0.147	3.863636
Time	.0333351*	.0167173	1.994	0.050	16.40523
Active	.3812733	1.342527	0.284	0.777	.6022727
Damage	1.288092*	.692187	1.861	0.066	.3863636
Threat	-.9204983	.7773883	-1.184	0.240	.7727273
NFI	.2786342	.6955211	0.401	0.690	.7045455
Florida	.868498	1.462367	0.594	0.554	.3409091
NC	1.721316	1.614911	1.066	0.290	.3522727
Constant	-1.919698	1.507175	-1.274	0.207	1

Dependent Variable = Indirect Role For Corps

Logit Estimates		Number of obs	=	88
		chi2(7)	=	5.09
Log Likelihood = -24.265105		Prob > chi2	=	0.7484

Variable Role 1	Coefficient	Std. Error	t	Prob > |t|	Mean .0909091
Bedrooms	.1934108	.2919426	0.662	0.510	3.863636
Time	.0064688	.0212824	0.304	0.762	16.40523
Active	-1.256985	1.755921	-0.716	0.476	.6022727
Damage	.7367777	.8566348	0.860	0.392	.3863636
Threat	1.55806	1.530063	1.018	0.312	.7727273
NFI	-.5285118	.9073003	-0.583	0.562	.7045455
Florida	3.023599	1.954897	1.547	0.126	.3409091
NC	3.243473	2.185824	1.484	0.142	.3522727
Constant	-6.027616*	2.663977	-2.263	0.026	1

TABLE 1 - FACTORS ASSOCIATED WITH RECOGNIZING THE CORPS (continued)

Dependent Variable = General or Specific Role For Corps

Logit Estimates

Log Likelihood = -41.270204

Number of obs = 88
chi2(7) = 16.43
Prob > chi2 = 0.0366

Variable Role 1	Coefficient	Std. Error	t	Prob > |t|	Mean .25
Bedrooms	-.5856481*	.259816	-2.254	0.027	3.863636
Time	.0279736*	.015712	1.780	0.079	16.40523
.Active	.4508802	1.314667	0.343	0.733	.6022727
Damage	.9754619	.6197625	1.574	0.120	.3863636
Threat	-.4806851	.7289252	-0.659	0.512	.7727273
NFI	-.0241782	.6268813	-0.039	0.969	.7045455
Florida	.1955841	1.358792	0.144	.0886	.3409091
NC	.862008	1.509705	0.571	0.570	.3522727
Constant	-.2623759	1.316257	-0.199	0.843	1

Dependent Variable = Any Mention of Role For Corps
General, Specific, or Indirect Role

Logit Estimates

Log Likelihood = -45.455354

Number of obs = 88
chi2(7) = 17.60
Prob > chi2 = 0.0244

Variable Role 1	Coefficient	Std. Error	t	Prob > |t|	Mean .3068182
Bedrooms	-.4130787*	.2205557	-1.873	0.065	3.863636
Time	.0289299*	0.155179	1.864	0.066	16.40523
Active	.1267734	1.103959	0.115	0.909	.6022727
Damage	1.054052*	.5902603	1.786	0.078	.3863636
Threat	-.2091963	.7101191	-0.295	0.769	.7727273
NFI	-.3066351	.6085547	-0.504	0.616	.7045455
Florida	1.338592	1.185299	1.129	0.262	.3409091
NC	1.669749	1.327445	1.258	0.212	.3522727
Constant	-1.075028	1.27076	-0.846	0.400	1

* - indicates estimate coefficient statistically significant at the 90% level.

NB: the significance level for the alternative hypothesis is indicated in the column of the table labeled Prob > |t|. So that if Prob > |t| is 0.1, then the estimate is significantly different from zero at the 90% level.

APPENDIX III-A

Survey Document Administered To Beachfront Homeowners
OMB 0710-0001

SHORELINE EROSION QUESTIONNAIRE OWNER'S VERSION

1. Circle the type of building that most closely matches your residence.

a. single family detached b. rowhouse or duplex c. mobile home
d. Low-rise multiple family (under 4 stories) e. Multifamily (4+ stories)

2. Does your property join the shoreline or a sand dune barrier?

______ a. Yes ______ b. No

3. How far is your residential structure from the high water shoreline? ______ (approximate distance in feet)

4. ______ Number of bedrooms (in your unit) ______ Number of bathrooms

5. How may years have you owned this housing unit ________ years

6. Is your property subject to flooding and/or erosion?

______ a. Yes ______ b. No ______ c. Do not know

7. Are you currently participating in the National Flood Insurance program?

______ a. Yes ______ b. No ______ c. Do not know

8. Do you know how much you pay for flood insurance on this housing unit?

______ a. Yes, you know ______ b. Do not know ______ c. Not insured

9. How important is the cost of insurance important in making decisions about this unit?

______ a. No effect on decisions b. ______ Very small effect
______ c. Moderate effect d. ______ Large effect on decisions

10. Has erosion or wave action caused significant damage to your property or to nearby property?

______ a. Yes ______ b. No ______ c. Do not know

1. If nearby property, how far away is the affected property? ______ (feet)

11. If your answer to the previous question was yes, what effect would these flooding or erosion problems have on the sales price or ease of sale if you attempted to sell your property?

______ a. No effect b. ______ Very small effect
______ c. Moderate effect d. ______ Large effect

12. Have you considered selling this property in the last five years?

______ a. Yes ______ b. No ______ c. Do not know

13. In this area, the primary beach season (when the beach is most heavily used and rents are high) lasts about ____________ weeks. The average weekly rent for this unit during the primary beach season is approximately $________ per week.

14. In this area, the secondary beach season lasts about __________ weeks. The average weekly rental for this unit during the secondary beach season is approximately $________ per week.

15. During the average summer week that you are in residence here, how many times do you and/or your family visit the local beach? _______ Please give the name of this local beach ___________

16. Do you believe that the character of the local beach is threatened by flooding and/or erosion?
______ a. Yes ______ b. No

17. Regarding your answer to the previous question, please indicate WHY you DO or DO NOT believe that flooding and/or erosion is a threat to the local beach. Please list all important reasons.

18. Do you know if any measures were taken by public agencies to reduce damages to the beach or to your residence?
______ a. Yes ______ b. No ______ c. Do not know

If you answered yes, what agency or agencies took the measures? ______________________________________

and what specific measures were taken?

19. Has your community done anything to combat the erosion problem?

______ a. Yes ______ b. No ______ c. Do not know

If you answered yes, what specific things have been done?

SECTION IV
ECONOMETRIC MODELS OF BEACHFRONT DEVELOPMENT

INTRODUCTION

As noted in Section II on economic theory and induced development, it is important to distinguish between beachfront development which is generated by shifting demand due to growth of the U.S. economy and induced growth from the cost advantages generated by shore protection projects. If induced development is a significant phenomenon, it should be possible to detect its effects on the economy of beachfront communities using standard local area econometric models. The most common econometric model relates changes in national economic activity and various local policy variables, the *exogenous variables*, to one or more indicators of local economic activity, the *endogenous variables*. Under the maintained hypothesis that cause and effect runs from exogenous to endogenous variables, statistical inference of the effect of exogenous changes on the local economy is straightforward.

Application of standard econometric techniques allows direct testing for the statistical significance of Corps actions, ranging from approval of a project, to periodic physical nourishment measured in tons of sand, through dollars of expenditure for protection, on the economy of a beachfront community. Thus, it is possible to estimate the size and significance of any induced development effects. The statistical test implicitly holds constant the stimulus to local development provided by general growth of income and employment in the national economy. It is important to differentiate between beachfront development that occurs after a Corps project, but which is due to general economic growth of income and employment, and any induced development which took place because of Corps activity. The results of such tests are reported in this section.

MODEL USED TO TEST FOR INDUCED LOCAL ECONOMIC EFFECTS

Small area econometric models have been used for a variety of purposes in the academic literature.[25] The most common endogenous variables include local employment, payrolls, output, personal income, population, earnings, tax revenue, and housing production. Most exogenous variables are based on the condition of the national economy and include aggregate output, employment, income, as well as national wage rates or earnings, interest rates, and the rate of inflation. Exogenous policy variables often reflect local area taxes and expenditures, transfers from and/or expenditures by the national government, as well as special regulations affecting the area. Thus, a typical equation of such a model would be:

Endogenous Variable = f(**Other Endogenous Var**, **Aggregate Economic Var**, **Policy Var**).

The entire model, consisting of a substantial number of such equations, can then be estimated using time series data from a given area.

The empirical problem in this study requires the estimation of induced economic effects on a local beachfront area economy associated with a particular set of public policy variables, reflecting the nature

[25] See, for example the excellent review of these models by Roger Bolton (1985) in the silver anniversary issue of the *Journal of Regional Science*.

and extent of Corps activity in the area. The question involves effects of Corps project activity, ranging from initial approval, to the first efforts at protection, through a series of periodic nourishment efforts. This question creates a number of substantial problems for statistical inference which are discussed sequentially below, along with the modeling solutions adopted.

First, the effect of a Corps project could be seen as a one-time discrete change in the time path of local development. In effect, the path of development would shift in a single discrete fashion perhaps shortly after approval or after initial implementation. This appears to suggest that a simple comparison of economic activity in a given locality before and after the Corps became active there would suffice for statistical inference. Unfortunately, in any given community, there may be other aspects which change profoundly at the same time that Corps activity changes. For example, the Corps might become active right after a major storm. Under such circumstances, the effects of the Corps would be confounded with the effects of the storm and the two effects could not be disentangled easily. Of course, one could select an area in which there were no other important changes at the same time that Corps activity began or changed. However, selection of such a community would introduce selection bias into the analysis and the results could not be generalized to all beach areas influenced by the Corps. The solution to this problem adopted here involves use of time series data from a number of areas, some that had Corps activity approved throughout the period, others where the Corps became active during the period, and a final group where the Corps was never active. Panel data allows one to avoid the problems arising because there is a correlation between variables reflecting the presence of the Corps in an area and other variables influencing economic activity in those areas. The panel data allows one to simultaneously make before vs. after and with vs. without comparisons and hence differentiate cases.

Second, the effects of Corps protection projects are likely to be concentrated in the first few hundred yards from the shoreline. Analyzing effects on the economy of a county which happens to have one shoreline border could easily miss the beachfront effects. Indeed, a county is likely to include both a beach area and an inland area as discussed in Section II above. To avoid this problem, the beachfront community was defined at the sub-county level, specifically at the level of urban places. Beachfront community was defined as an urban place in which economic activity was concentrated near, and dependent upon, a local beach area.

Third, if a panel of areas is to be selected for analysis, some method must be found for drawing an unbiased sample of areas to be analyzed. If a sample were selected consisting of the slowest growing areas in which the Corps had been active and the fastest growing areas where the Corps has been inactive, estimates of the effects of Corps projects on local economic growth would be biased downward. In order to insure a sample of areas in which the probability of selection was independent of both the level of Corps activity and the rate of economic growth, a sample of beachfront communities was selected based on data availability alone. Beachfront communities were defined as urban places for which annual data was readily available. All beachfront communities along the coast from New York to Louisiana for which time series data on critical variables was available, extending back to 1960, were selected for the panel. This produced a sample of 42 beachfront communities for which time series data from 1960 to 1992 were collected.

Fourth, there is a special problem in the choice of endogenous variables to be used to characterize the level of economic activity in a beachfront community. Unfortunately, seasonality in the demand for beach services is very important, i.e. there is usually a very large summer peak in income, output, employment, etc. Induced economic effects should be measured during the summer peak when the effects of shore protection should be largest. Unfortunately, virtually all economic time series collected for the urban places, i.e. the beachfront communities analyzed here, are collected in the winter or spring. For example, employment and earnings data are based on a March survey. Therefore, these variables are inappropriate for the study of effects on the summer peak in beachfront economic activity. The one exception to these data problems is building permit data which is collected on an annual basis. Also housing stock data, which may be collected in the spring, is not subject to the summer peak problem that biases other data series. Fortunately, the residential real estate market is directly related to the issue of induced development and subsequent storm damage that has prompted this study. Accordingly housing stock and new housing permits were both used as independent variables in the analysis performed here.

All these considerations led to the specification and estimation of the following general function in order to determine the importance of induced development effects:

NEW HOUSES = F(**Corps Activity**, **Flood Insurance**, **Aggregate Economy**, **Storm Activity**)

The dependent variable is the number of permits for new housing units issued in the beachfront community each year. Groups of independent variables reflect the presence and level of Corps activity, status of flood insurance in the community, state of the aggregate economy, and level of recent storm activity experienced in the beachfront area. In addition, as is customary with panel data, dummy variables reflecting location in various beachfront areas were forced into the estimates. Both linear and double-log functions were chosen in order to explore alternative possibilities for the form of $F(\cdot)$.

One important principle of model specification was the prior selection of variables to be used in the analysis based on economic theory and data availability. The estimation process followed here began with specification of possible equations based on both the theory section and the literature. The choice of estimation technique also followed from the literature. The final model estimated was based on these prior considerations and data availability which is discussed below. One set of estimation results was produced and there was no attempt to rework these results based on the results obtained for various hypothesis tests. No additional data was collected or variables added once the initial set of hypothesis tests, which were planned *a priori* were completed. Therefore, the test statistics reported can be applied in a straightforward fashion to evaluation of the significance of individual variables.

Finally, in testing for possible effects of Corps activity on induced development, the statistical procedures were inclusive. That is, a variety of variables reflecting different possible aspects of Corps activity were forced into the estimates to determine if any had the hypothesized positive and significant relation to development. Given the level of ambiguity concerning the manner in which the policy variables reflecting Corps activity might affect expectations for the future of a beach area, a number of possible variables reflecting different aspects of Corps projects were tested.

DATA USED TO ESTIMATE THE MODEL

The 42 beachfront communities which constituted the sample used here were selected based on data availability and are listed in Appendix IV-A to this section. The time period covered includes 1960 to 1992, yielding 33 observations for each area. The sample includes communities where the Corps was active for the entire period, areas where the Corps had no authorization to act, and communities in which the Corps gained authorization during the 1960 to 1992 period covered by the sample. Within the panel of communities, it is possible to observe cases of development both before and after Corps projects as well as with and without Corps activity.

New beachfront development is measured by the number of new housing units authorized by building permits during a given year. The building permit data includes units in both single family and multi-family structures. If there is substantial induced development it should be evident in the building permit data. These are annual data and are not subject to problems of seasonal peaks that render use of other indicators of beachfront community development questionable.

In order to detect any possible influence of Corp activity on beachfront communities, a variety of indicators of the Corps' presence were selected using tabulations supplied by the Corps. The specific variables used include: **TSAND**, tons of sand used in beach nourishment each year; **TCOST**, total cost of nourishment in 1994 dollars each year; **YRAUTH**, a dummy variable equal to unity only in the year when the project was initially authorized and zero otherwise; **YRMOD**, a dummy variable equal to unity in any year in which the project authorization was modified and zero otherwise; and **ACTIVE**, a dummy variable equal to unity in any year when the Corps project was active in the community (beginning with the date of authorization) and zero at other times. Taken together these variables appear to reflect the various ways in which Corps activity could reduce expectations of future losses that could stimulate induced development as described by the theory in Section II.

In addition to Corps activity, the second category of government policy variable which was tested for possible influence on beachfront development was the National Flood Insurance program. **NFI** is a dummy variable equal to unity in years when the community participated in the National Flood Insurance program and zero in earlier years. **FEMAP** is a dummy variable equal to unity in years when a completed flood insurance map was available and zero otherwise. Information necessary for coding these variables was taken directly from microfiche records supplied by the Federal Emergency Management Agency.

Following analysis of the variables reflecting Corps activity and the status of National Flood Insurance, the third category of variables entering the model measure effects of changes in aggregate economic activity on development in the beachfront communities. These variables reflect the effects of general economic growth in the economy on beachfront community development. National income and employment are traditionally used as exogenous measures on aggregate economic activity in local area econometric models. However, if beachfront community development follows the results in the general literature on small area economic growth models, the primary determinants of local development are measures of the effects of aggregate income and employment growth in the economy. In terms of the theoretical model in Section II, general economic growth effects shift the aggregate demand curve for beach services, raising their price and stimulating development at all beachfront locations, regardless of the level of Corps activity.

Following the literature on demand for recreation services, the effects of aggregate economic growth on the demand for beachfront recreation services (broadly defined) and on beachfront community economic development is based on proximity or travel cost. Put another way, high growth in Atlanta or Buffalo has a more substantial effect on demand for beaches in Florida than does growth in San Francisco. Therefore, a shift in economic growth from New York to California may have a negative effect on development of beachfront communities in Florida. Consequently, the variables reflecting demand due to aggregate income and employment effects were based on a proximity-weighted index of changes in income and employment in metropolitan areas east of the Mississippi River. Proximity weights were estimated based on travel cost and intervening opportunities and the final index of demand for beachfront community i in year t based on income change was computed as $\mathbf{DINCOME}_{it} = \Sigma_j w_{ij}\,\mathrm{INCOME}_{jt}$, where w_{ij} is the proximity weight connecting beachfront community i and metropolitan area j, and INCOME_{jt} is personal income in metropolitan area j in year t. Similarly, the final index of demand for beachfront community i in year t based on employment change was computed as $\mathbf{DEMPLOY}_{it} = \Sigma_j w_{ij}\,\mathrm{EMPLOY}_{jt}$, where w_{ij} is the proximity weight connecting beachfront community i and metropolitan area j, and EMPLOY_{jt} is total non-agricultural employment in metropolitan area j in year t.

It is also possible that storms could have a significant effect on development in beachfront areas. Certainly, storm damage could make the beachfront less attractive, perhaps also raising expectations for future damage and, hence, lower beachfront development. However, it is also possible for storm damage to prompt a wave of rebuilding which would result in issuance of a significant number of new building permits. Thus, the final effect of storms on the measure of development used here is likely negative but may not be as significant as expected. Two measures of storm intensity in each beachfront community were used. **STORM1** is an index, ranging from 1 to 5, of the strength of any hurricane force tropical storm which reached a landfall in the county in which the beachfront community is located in the year in question. It is set equal to zero for any year in which there was no landfall by a hurricane strength storm in the county. **STORM2** is an index of storm damage to the beachfront area available only for areas with authorized Corps projects. It is set equal to zero for areas lacking Corps authorized projects. There is significant measurement error involved in the use of either of these storm damage indexes. **STORM1** ignores damage by storms which are not hurricanes and **STORM2** does not measure damage in areas lacking Corps activity. Measurement error in these independent variables should bias estimated coefficients toward the null hypothesis.

The estimating equations also include a time trend, **TIME**, and a series of zero-one dummy variables for the various states in which beachfront communities are located, West Florida (**WEST FLA**), East Florida (**EAST FLA**), South Florida (**SOUTH FLA**), Maryland (**MD**), New York (**NY**), New Jersey (**NJ**), North Carolina (**NC**), and South Carolina (**SC**).[26] The constant term reflects the reference state,

[26]Location dummies are based on states, reflecting differences in regulations that affect residential development. Given the number of Florida communities in the sample and the substantial distances between these areas, three location dummies were inserted for Florida.

Virginia. State location dummy variables should be associated with differences in local economic activity, infrastructure development, taxes and subsidies, zoning and land development policy, etc.

ESTIMATION RESULTS

The estimation results are presented in Table 2. The presentation proceeds in a series of steps beginning with a very simple model that includes only variables reflecting Corps activity through a final model that includes all variables discussed above and reflects National Flood Insurance programs, aggregate economic activity, storms, as well as time trend and state location. The large model presented at the end of Table 2 is certainly the most appropriate because it includes the influence of growing income and employment in inland areas on the demand for beachfront housing. However, the simple models which include only Federal government policy variables are presented initially so that the interaction between the estimated coefficients of these models and variables reflecting economic growth may be observed. Two functional forms, linear and double-logarithmetic, are tested. In the linear model, estimated coefficients reflect the relation between changes in the level of the independent variables and change in the level of new residential construction. In the log-linear model, estimated coefficients reflect the relation between percentage changes in the independent variables and the percentage change in new residential construction. The addition of an "L" as a prefix to the name of a variable indicates that it is the logarithm of the variable.[27]

First, and most important for this study, are the variables reflecting various aspects of Corps activity including **TSAND**, **TCOST**, **YRAUTH**, **YRMOD**, and **ACTIVE**. It may appear that **TSAND** has a generally positive and significant effect on new housing while **TCOST** has a corresponding negative and significant effect. However, the estimated coefficients for these two variables should be considered together because a change in sand moved implies a change in project cost. Examination of their estimated coefficients of the double-log form in sections C and D in Table 2 indicates that they are approximately equal in magnitude and opposite in sign. The estimated coefficients of the double-log form can be interpreted as elasticities of new housing with respect to the independent variable, i.e. the percentage change in new housing generated by a one percentage point change in the independent variable. Therefore, the implication of these equal and opposite signs for the estimated coefficients of **LTSAND** and **LTCOST** in the double-log form is that a one percent increase in tons of sand and a one percent rise in total cost leave new housing permits unchanged. But if the price of sand is constant, then tons of sand and total cost should both change by a corresponding percentage and the positive and significant estimated coefficient for **LTSAND** does not imply that projects which add more sand for nourishment purposes results in additional residential housing because such projects also result in greater cost. This interpretation is easily confirmed by estimating the same models with **LTCOST** removed and noting that the estimated coefficient of **LTSAND** is then non-significant. One interpretation for these estimation results is that, in areas where periodic nourishment is relatively inexpensive, more development takes place than in areas where nourishment is relatively costly.

[27] In cases where a variable may take on a value of zero, the prefix "L" added to the variable name indicates the logarithm of the one plus the variable so that the logarithmic transformation can be performed.

Initial authorization of a project, **YRAUTH**, generally has a negative and sometimes significant relation to higher levels of development. Overall, there does not appear to be a consistent relation between **YRAUTH** and residential real estate activity in these communities. Effects of modifications in the nature of Corps activity, reflected in the estimated coefficient of **YRMOD**, appear to bear a negative and marginally significant relation to permits.

Finally, the general indicator for periods of Corps activity, **ACTIVE**, is positively related to new housing in simple versions of the linear model, i.e., versions "A" and "B." Considering all the evidence in **ACTIVE** appears to have no significant relation to development. The estimated coefficient of **ACTIVE** is non-significant in all versions of the double-log model and the extended form of the linear model.

Overall, these estimation results appear consistent with the null hypothesis that, at the level of the entire beachfront community, the presence of a Corps project has little effect on new housing production. Thus, it appears that the induced effect of the projects analyzed in this sample is, at most, very small. This is consistent with survey results which suggest that, in areas where storm damage and beach erosion are perceived as problems, prior Corps activity in the area is not related to the perception that the Corps is likely to cure future problems.

In order to evaluate the econometric results presented here, it is useful to consider the overall agreement of the estimates with prior expectations. It is possible that the estimated coefficients of Corps activity variables indicate that there is little or no significant induced effect on beachfront community development because the overall explanatory power of the estimated equations was small. Estimation results for the expanded model including exogenous variables reflecting more than Corps activity are presented in sections "C" and "D" of Table 2.

In addition to indicators of Corps activity, the other national government policy variables, **NFI** and **FEMAP**, indicate significant dates in the provision of National Flood Insurance. For both the linear and double-log forms of the expanded model, the estimated coefficient of **NFI** is positive and significant. Furthermore, its magnitude indicates a large effect on development. The estimated coefficient of **FEMAP** is generally nonsignificant. These estimation results indicate that initial approval of a community for the National Flood Insurance program had a significant positive effect on residential development, but that publication of the first flood maps had no effect. This result is plausible given that, between its initiation in 1968 and significant changes in 1974, the National Flood Insurance program had a significant subsidy component but publication of flood maps might acquaint residents with hazards and, hence, depress development.

The estimated coefficients of the two storm indicator variables, **STORM1** and **STORM2**, indicate that the second variable is most effective in reflecting the short-term effects of serious storms. The estimated coefficient of **STORM2** is negative and significant in both the linear and double-log forms in section D of Table 2. It is important to remember that the expected sign of these coefficients was in doubt because storm activity can have multiple effects on new residential construction. Major storms can depress activity by raising expectations for future losses. However, the short run effect of storms is expected to be negative while, in the long run storm damage can stimulate replacement construction projects and/or actual damage can be less than expected and, hence, expectation of future losses can actually fall. This may explain why **STORM2,** which is a measure of actual storm damage, was more likely to have a negative and significant effect than **STORM1** which was simply a measure of storm intensity independent of damage done.

The effects of the aggregate economy on beachfront community development are most important. The indexes of proximity-weighted demand based on income and employment, specifically **DINCOME** and **DEMPLOY,** are positive, have estimated coefficients in section D of Table 2 that are statistically significant, and large. It is apparent that residential development of beachfront communities is driven by a large economic growth effect from metropolitan areas east of the Mississippi River. In the double-log version of the new housing equation, the estimated coefficient of **LDINCOME** (the logarithm of **DINCOME**) is 0.17 and the estimated coefficient of **LDEMPLOY** is 0.20. These estimated coefficients can be interpreted as elasticities of residential construction with respect to the exogenous variables. Therefore, the estimates imply that a 10% rise in weighted real income in metropolitan areas in the east generates a 1.7% rise in new construction in beachfront communities and a 10% rise in employment in these same metropolitan areas generates a 2.0% rise in new construction in the same beachfront communities. This increase in construction occurs independent of the state of Corps activity in the communities.

These econometric results suggest a possible source of confusion regarding the importance of induced development. Certainly, many beachfront communities have experienced substantial residential development following the approval and implementation of Corps shore protection projects. However, such development is generated by growth of income and employment in inland areas and would have taken place without the Corps projects. Indeed, high levels of development have occurred in areas where the Corps has never been active and in areas that have rejected the notion of asking the Corps for shore protection. The fact that development follows implementation of Corps projects does not prove causality. To confuse what follows Corps activity with the causal effects of such activity is to commit the classic fallacy *post hoc, ergo propter hoc*, i.e. the fact that events follow in time does not mean that they are causally related. The econometric results presented here imply that general economic growth of inland communities is sufficient by itself to drive residential development of beachfront areas at a rapid pace.

A final indicator of the overall validity of an econometric model is the general test statistics measuring goodness of fit. For the extended models these statistics are quite satisfactory. Both the F-statistic and the coefficient of determination are quite large given a sample which pools time series data across a panel of areas and the fact that lagged values of the dependent variable are not used as arguments of the regression. The estimated equations appear to provide a satisfactory description of the determinants of differences in new residential development across communities and over time.

TABLE 2 - Determinants of New Residential Building - Permits in Beachfront Communities

A. ESTIMATES USING ONLY CORPS ACTIVITY VARIABLES

Linear Model

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
NEWHOUSE					389.7872
TSAND	.064498	.1292615	0.499	0.618	76.87049
TCOST	-.0130583	.014242	-0.917	0.359	708.5938
YRAUTH	33.30272	151.1374	0.220	0.826	.021645
YRMOD	-374.2743	235.9832	01.586	0.113	.008658
ACTIVE	237.3648*	45.44739	5.223	0.000	.466811
CONSTANT	285.7973*	30.45336	9.385	0.000	1
Number of obs = 1386		F(5, 1380) = 5.89		Prob > F = 0.0000	
R-square = 0.0209		Adj R-square = 0.0173		Root MSE = 810.83	

Double Log Model

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
LNEWHOUSE					4.842448
TSAND	.2762271*	.0681952	4.051	0.000	.5101688
TCOST	-.2011257*	.0496944	-4.047	0.000	.8241782
YRAUTH	-.1812183	.2982113	-0.608	0.543	.021645
YRMOD	-.9017528*	.4722832	-1.909	0.056	.008658
ACTIVE	.0118803	.0935026	0.127	0.899	.466811
CONSTANT	4.873473*	.0600881	81.106	0.000	1
Number of obs = 1386		F(5, 1578) = 4.94		Prob > F = 0.0002	
R-square = 0.0176		Adj R-square = 0.0140		Root MSE = 1.5999	

TABLE 2 - Determinants of New Residential Building - Permits in Beachfront Communities

B. ESTIMATES USING CORPS ACTIVITY AND FLOOD INSURANCE VARIABLES

Linear Model

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
NEWHOUSE					389.7872
TSAND	.0645506	.1294549	0.499	0.618	76.87049
TCOST	-.01307	.0143056	-0.914	0.361	708.5938
YRAUTH	33.53691	151.827	0.221	0.825	.021645
YRMOD	-374.4191	236.5784	-1.583	0.114	.008658
ACTIVE	237.1739*	47.0226	5.044	0.000	.466811
NFI	1.206754	92.16171	0.013	0.990	.6507937
FEMAP	-.4416711	88.91244	-0.005	0.996	.5829726
CONSTANT	285.3591*	39.83982	7.163	0.000	1

Number of obs = 1386 F(7, 1378) = 4.20 Prob > F = 0.0002

R-square = 0.0209 Adj R-square = 0.0159 Root MSE = 811.42

Double Log Model

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
LNEWHOUSE					4.842448
TSAND	.274452*	.068211	4.024	0.000	.5101688
TCOST	-.195534*	.0497962	-3.987	0.000	.8241782
YRAUTH	-.1578954	.2993581	-0.527	0.598	.021645
YRMOD	-.8961543*	.4729092	-1.895	0.058	.008658
ACTIVE	.0012721	.0960856	0.013	0.989	.466811
NFI	.2528726	.1818292	1.391	0.165	.6507937
FEMAP	-.2232901	.1755789	-1.272	0.204	.5829726
CONSTANT	4.842261*	.0785391	61.654	0.000	1

Number of obs = 1386 F(7, 1378) = 3.81 Prob > F = 0.0005

R-square = 0.0190 Adj R-square = 0.0140 Root MSE = 1.5999

* indicates that the estimated coefficient is statistically significant at the 90% level

TABLE 2 - Determinants of New Residential Building - Permits in Beachfront Communities

C. ESTIMATES USING CORPS ACTIVITY AND FLOOD INSURANCE VARIABLES ALONG WITH TIME TREND AND STATE DUMMY VARIABLES

Linear Model

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
NEWHOUSE					389.7872
TSAND	.1055238	.0973705	1.084	0.279	76.87049
TCOST	-.0182877*	.0107706	-1.698	0.090	708.5938
YRAUTH	-74.43573	109.4164	-0.680	0.496	.021645
YRMOD	-266.8399	170.2807	-1.567	0.117	.008658
ACTIVE	19.12682	38.10312	0.502	0.616	.466811
NFI	12.52976	80.80765	0.155	0.877	.6507937
FEMAP	67.85086	71.44683	0.950	0.342	.5829726
TIME	19.1825*	3.31666	-5.770	0.000	17
WEST FLA	-3612.837*	107.7954	-33.516	0.000	.2380952
EAST FLA	-3657.339*	109.7597	-33.321	0.000	.2142857
SOUTH FLA	-3333.314*	107.8389	-30.910	0.000	.2380952
NY	-3559.875*	128.6531	-27.670	0.000	.047619
NJ	-3721.507*	113.6619	-32.742	0.000	.1190476
MD	-3244.585*	146.4474	-22.155	0.000	.0238095
NC	-3832.483*	125.4388	-30.553	0.000	.047619
SC	-3682.554*	129.3887	-28.461	0.000	.047619
CONSTANT	3671.051*	117.4749	31.250	0.000	1
Number of obs = 1386		F(16, 1369) = 80.56		Prob > F = 0.0000	
R-square = 0.5003		Adj R-square = 0.4941		Root MSE = 581.80	

Double Log Model

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
LNEWHOUSE					4.842448
TSAND	.1285279*	.0631301	2.036	0.042	.5101688
TCOST	-.1672128*	.0463393	-3.608	0.000	.8241782
YRAUTH	-.3163906	.2731474	-1.158	0.247	.021645
YRMOD	-.9089958*	.4316965	-2.106	0.035	.008658
ACTIVE	-.108045	.0964888	-1.120	0.263	.466811
NFI	.3336622*	.1851197	1.802	0.072	.6507937
FEMAP	-.1475288	.1659869	-.889	0.374	.5829726
LTIME	-.0349289	.0849187	-0.411	0.681	2.577408
WEST FLA	-3.894016*	.2821614	-13.801	0.000	.2380952
EAST FLA	-3.759197*	.2838714	-13.243	0.000	.2142857
SOUTH FLA	-3.113222*	.2784612	-11.180	0.000	.2380952
NY	-3.386219*	.3318719	-10.203	0.000	.047619
NJ	-4.209176*	.297088	-14.168	0.000	.1190476
MD	-2.797112*	.3720411	-7.518	0.000	.0238095
NC	-4.546761*	.3166344	-14.360	0.000	.047619
SC	-3.896039*	.333137	-11.695	0.000	.047619
CONSTANT	8.54364*	.303013	28.196	0.000	1
Number of obs = 1386		F(16, 1369) = 20.82		Prob > F = 0.0000	
R-square = 0.1957		Adj R-square = 0.1863		Root MSE = 1.4534	

* indicates that the estimated coefficient is statistically significant at the 90% level

TABLE 2 - Determinants of New Residential Building - Permits in Beachfront Communities

D. ESTIMATES USING CORPS ACTIVITY, FLOOD INSURANCE, AND DEMAND AND STORM DAMAGE VARIABLES ALONG WITH TIME TREND AND STATE DUMMY VARIABLES

Linear Model With Demand Driven by Employment Growth

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
NEWHOUSE					389.7872
TSAND	.1225096	.099211	1.235	0.217	76.87049
TCOST	-.0225531*	.0109019	-2.069	0.039	708.5938
YRAUTH	-114.2679	109.7862	-1.041	0.298	.021645
YRMOD	-251.398	172.2112	-1.460	0.145	.008658
ACTIVE	48.50302	37.82735	1.282	0,200	.466811
NFI	203.0134*	70.91693	2.862	0.004	.6507937
FEMAP	73.49837	71.38072	1.030	0.303	.5829726
STORM1	29.37165	26.35208	1.115	0.265	.1544012
STORM2	-105.7905*	63.03167	-1.678	0.094	.0425685
DEMPLOY	.4030984*	.0766931	5.256	0.000	222.2303
TIME	-14.27453*	3.267929	-4.368	0.000	17
WEST FLA	-3106.667*	142.2071	-21.846	0.000	.2380952
EAST FLA	-3165.935*	140.8296	-22.481	0.000	.2142857
SOUTH FLA	-2863.473*	137.234	-20.866	0.000	.2380952
NY	-3034.494*	159.3036	-19.048	0.000	.047619
NJ	-3280.401*	138.6808	-23.654	0.000	.1190476
MD	-3492.877*	155.0659	-22.525	0.000	.0238095
NC	-3332.828*	154.6834	-21.546	0.000	.047619
SC	-3360.976*	140.4092	-23.937	0.000	.047619
CONSTANT	3393.263*	142.2125	23.861	0.000	1

Number of obs = 1386 F(19, 1366) = 72.69 Prob > F = 0.0000

R-square = 0.5027 Adj R-square = 0.4958 Root MSE = 580.80

* indicates that the estimated coefficient is statistically significant at the 90% level

TABLE 2 - Determinants of New Residential Building - Permits in Beachfront Communities

D. ESTIMATES USING CORPS ACTIVITY, FLOOD INSURANCE, AND DEMAND AND STORM DAMAGE VARIABLES ALONG WITH TIME TREND AND STATE DUMMY VARIABLES

Linear Model With Demand Driven by Income Growth

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
NEWHOUSE					389.7872
TSAND	.1147445	.0993089	1.155	0.248	76.87049
TCOST	-.0211474*	0.109008	-1.940	0.053	708.5938
YRAUTH	-121.6471	109.9249	-1.107	0.269	.021645
YRMOD	-249.1657	172.3571	-1.446	0.149	.008658
ACTIVE	54.27997	37.87795	1.433	0.152	.466811
NFI	216.6493*	70.99608	3.052	0.002	.6507937
FEMAP	70.44238	71.42768	0.986	0.324	.5829726
STORM1	25.34954	26.39739	0.960	0.337	.1544012
STORM2	-102.6592*	63.07374	-1.628	0.104	.0425685
DINCOME	1.119225*	.2229013	5.021	0.000	57.9235
TIME	-16.6985	3.369991	-4.955	0.000	17
WEST FLA	-3243.434*	128.5078	-25.239	0.000	.2380952
EAST FLA	-3292.983*	128.6837	-25.590	0.000	.2142857
SOUTH FLA	-2984.309*	125.8595	-23.711	0.000	.2380952
NY	-3184.086*	145.8203	-21.836	0.000	.047619
NJ	-3369.543*	131.2019	-25.682	0.000	.1190476
MD	-3291.247*	146.968	-22.394	0.000	.0238095
NC	-3525.06*	133.0391	-25.506	0.000	.047619
SC	-3492.335*	133.0391	-26.250	0.000	.047619
CONSTANT	3566.564*	125.0598	28.519	0.000	1

Number of obs = 1386	F(19, 1366) = 72.43	Prob > F = 0.0000
R-square = 0.5019	Adj R-square = 0.4949	Root MSE = 581.30

* indicates that the estimated coefficient is statistically significant at the 90% level

TABLE 2 - Determinants of New Residential Building - Permits in Beachfront Communities

D. ESTIMATES USING CORPS ACTIVITY, FLOOD INSURANCE, AND DEMAND AND STORM DAMAGE VARIABLES ALONG WITH TIME TREND AND STATE DUMMY VARIABLES

Double Log Model With Demand Driven By Employment Growth

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
NEWHOUSE					4.842448
LTSAND	.1317549*	.0626096	2.104	0.036	.5101688
LTCOST	-.1662381*	.0459951	-3.614	0.000	.8241782
YRAUTH	-.3499372	.2719229	-1.287	0.198	0.21645
YRMOD	-.8012403*	.4320752	-1.854	0.064	.008658
ACTIVE	-.0706443	.0958217	-0.737	0.461	.466811
NFI	.313942*	.1835137	1.711	0.087	.6507937
FEMAP	-.1625444	.1644793	-0.988	0.323	.5829726
LSTORM1	.0670711	.0654757	1.024	0.306	.1544012
LSTORM2	-6.119795*	.2790012	-2.193	0.028	.0247323
LDEMPLOY	.1951873*	.0396918	4.918	0.000	4.487639
LTIME	-.0656433	.084936	-0.773	0.440	2.577408
WEST FLA	-3.234556*	.3015899	-10.516	0.000	.2380952
EAST FLA	-3.171374*	.3015899	-10.516	0.000	.2142857
SOUTH FLA	-2.576936*	.2933138	-8.786	0.000	.2380952
NY	-2.64167*	.3574655	-7.390	0.000	.047619
NJ	-3.6496*	.3122149	-11.689	0.000	.1190476
MD	-2.837016*	.3698573	-7.671	0.000	.0238095
NC	-3.933733*	.3355893	-11.752	0.000	.047619
SC	-3.406025*	.3421078	-9.956	0.000	.047619
CONSTANT	7.188815*	.3953833	18.182	0.000	1

Number of obs = 1386 F(19, 1366) = 19.45 Prob > F = 0.0000

R-square = 0.2129 Adj R-square = 0.2020 Root MSE = 1.4393

* indicates that the estimated coefficient is statistically significant at the 90% level

TABLE 2 - Determinants of New Residential Building - Permits in Beachfront Communities

D. ESTIMATES USING CORPS ACTIVITY, FLOOD INSURANCE, AND DEMAND AND STORM DAMAGE VARIABLES ALONG WITH TIME TREND AND STATE DUMMY VARIABLES

Double Log Model With Demand Driven By Income Growth

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
NEWHOUSE					4.842448
LTSAND	.136205*	.0628502	2.167	0.030	.5101688
LTCOST	-.1685439*	.0462128	-3.647	0.000	.8241782
YRAUTH	-.3520084	.27299	-1.289	0.197	0.21645
YRMOD	-.7784236*	.4337647	-1.795	0.073	.008658
ACTIVE	-.0680478	.0964501	-0.706	0.481	.466811
NFI	.3200446*	.1842608	1.737	0.083	.6507937
FEMAP	-.222441	.1660494	-1.340	0.181	.5829726
LSTORM1	.0885788	.0852358	1.039	0.299	.120004
LSTORM2	-.6221634*	.2801718	-2.221	0.027	.0247323
LDINCOME	.1687254*	.0464011	3.636	0.000	3.150971
LTIME	-.0959131	.0872685	-1.099	0.272	2.577408
WEST FLA	-3.33039*	.3127567	-10.649	0.000	.2380952
EAST FLA	-3.25483*	.3077755	-10.575	0.000	.2142857
SOUTH FLA	-2.660056*	.2979054	-8.929	0.000	.2380952
NY	-2.884983*	.3519592	-8.197	0.000	.047619
NJ	-3.677426*	.3233194	-11.374	0.000	.1190476
MD	-2.778978*	.3709214	-7.492	0.000	.0238095
NC	-4.165021*	.3297802	-12.630	0.000	.047619
SC	-3.60674*	.3379658	-10.672	0.000	.047619
CONSTANT	7.734884*	.3601105	21.479	0.000	1

Number of obs = 1386   F(19, 1366) = 19.45   Prob > F = 0.0000

R-square = 0.2068   Adj R-square = 0.1957   Root MSE = 1.4449

* indicates that the estimated coefficient is statistically significant at the 90% level

APPENDIX IV-A - DATA DOCUMENTATION FOR BEACH PROJECT

Data Set On Beachfront Communities

I. Variables

1. A. **SITE** = Site number, 1-57 see key below
2. B. **YEAR** = Year 1970-1992
3. C. **DTOT** = dummy for total change in new units estimated 1=yes
4. D. **DTYP** = dummy for change in new units by type estimated 1=yes
5. E. **HOUSES** = estimated stock of housing units in community
6. F. **NEWH** = total new units added during the year
7. G. **NEWSH** = new single unit structures added during the year
8. H. **NEW2H** = new units in 2-4 unit structures added during the year
9. I. **NEW5H** = new units in 5+ unit structures added during the year
10. J. **TSAND** = total sand in thousands of cubic yards added during the year
11. K. **FCOSTR** = federal cost of restoration performed during the year
12. L. **TCOSTR** = total cost of restoration performed during the year
13. M. **FCOSTN** = federal cost of nourishment during year
14. N. **TCOSTN** = total cost of nourishment during year
15. O. **FCOST** = sum of federal costs during year
16. P. **TCOST** = sum of total costs during year
17. Q. **STORMD** = Storm damage during year
18. R. **YRAUTH** = year project authorized dummy, 1=year initially authorized
19. S. **YRMOD** = year project modified dummy, 1=year authorization modified
20. T. **DIT** = Teresa's income demand
21. U. **DIE** = Ethan's income demand
22. V. **DET** = Teresa's employment demand
23. W. **DEE** = Ethan's employment demand
24. X. **FEMA1** = dummy variable for initiation of FEMA insurance
25. Y. **FEMAP** = dummy variable for initial FEMA map available
26. Z. **STORM** = indicator variable for major storm equal to hurricane strength on scale of 1-5, and 0 if no hurricane.

II. Selected Beachfront Communities:

CITY	COUNTY
FLORIDA	
1. Anna Maria Manatee	
2. Atlantic Beach	Duval
3. Bal Harbor	Dade
4. Bellaire, dropped	
5. Boca Raton	Palm Beach
6. Boynton Beach	Palm Beach
7. Bradenton	Manatee
8. Clearwater	Pinellas
9. Cocoa Beach	Brevard
10. Daytona Beach	Volusia
11. Delray Beach	Palm Beach
12. Ferandina Beach	Nassau
13. Holmes Beach	Manatee
14. Indian Rocks Beach	Pinellas
15. Jacksonville Beach	Duval
16. Juno Beach, dropped	
17. Long Boat Key	Manatee
18. Melbourne Beach	Brevard
19. Miami Beach	Dade
20. Naples	Collier
21. Neptune Beach	Duval
22. New Smyrna Beach	Volusia
23. North Miami Beach	Dade
24. North Reddington, dropped	
25. Ormond Beach	Volusia
26. Panama City	Bay
27. Riviera Beach	Palm Beach
28. Reddington, dropped	
29. St. Petersburg	Pinellas
30. Treasure Island	Pinellas
31. Venice	Sarasota
32. Vero Beach	Indian River
33. West Palm Beach	Palm Beach
LOUISIANA	
34. Grand Island, dropped	

MARYLAND	
35. Ocean City	Worcester
NEW JERSEY	
36. Cape May, dropped	
37. Key Port, dropped	
38. Long Beach Township	Ocean
39. Long Branch	Monmouth
40. Ocean City	Cape May
41. Sea Isle City	Cape May
42. Union Beach	Monmouth
NEW YORK	
43. Bayville, dropped	
44. Long Beach	Nassau
45. Sag Harbour, dropped	
46. Sands Point, dropped	
47. Southampton	Suffolk
NORTH CAROLINA	
48. Carolina Beach	New Hanover
49. Southport, dropped	
50. Wrightsville Beach	New Hanover
SOUTH CAROLINA	
51. Isle of Palms	Charleston
52. Myrtle Beach	Horry
53. North Myrtle Beach, dropped	
54. Surf Side Beach, dropped	
VIRGINIA	
55. Hampton, dropped	
56. Newport News, dropped	
57. Virginia Beach	Virginia Beach City

SECTION V
ECONOMETRIC ANALYSIS OF BEACHFRONT HOUSING PRICES

INTRODUCTION

The econometric model of beachfront community development in the previous section allows a direct test of the hypothesis that shore protection projects generate induced development. However, it is also common to use indirect tests for the neighborhood effects of public projects. These indirect tests are based on spatial house price responses and, hence, require estimation of the spatial distribution of house prices and the statistical test attempts to find a relation between proximity to the public project and changes in house prices. The problem of testing for the economic effects of shore protection projects appears to fit the assumptions of the house price approach.

This section presents the results of a test for the economic effects of shore protection projects on induced development using the spatial house price change approach. A first step in this testing effort is the estimation of spatial house price change indexes for three Florida counties in which the Corps has been active. This is a major data processing and statistical estimation effort. Then, tests are performed to determine if the differential between inland and beachfront house price changes is related to the level of shore protection activity. Tests using spatial house price changes should be even more sensitive measures of shore protection effects than the econometric modeling in the previous section. First, it is possible to estimate price changes out to the limit of development, in the "first row" of residences. Second, price changes are more flexible and immediate than changes in new construction. Even if coastal development regulations severely limit the ability to increase development along the beachfront and effectively prevent significant amounts of induced development, spatial house price index measures will still show the effects of shore protection on expected future losses in the manner described in Section II.

ESTIMATION OF BEACHFRONT HOUSE PRICE INDEXES

Given the goal of estimating the spatial relation between distance from the shoreline and changes in house prices over time, a special, statistical technique for estimating house price indexes was employed.[28] The repeat sales method first introduced by Bailey, Muth and Nourse (1963), produces an index by following the changes in prices of homes that sell more than once over the interval being studied. Applications and improvements to the repeated sales price method by Case and Shiller (1989), Case, Pollakowski and Wachter (1991), and Case and Quigley (1991) have drawn attention to the advantages of this technique. However, repeat sale index construction requires the availability of special data sets in machine readable form. Data availability was a major factor in determining the locations which could be analyzed and the time periods covered. The steps in the estimation of beachfront house price change indexes, beginning with sample selection, are discussed in this subsection.

The repeat sales price indexes used here were constructed by Professor Dean Gatzlaff, Department of Insurance, Real Estate, and Business Law, College of Business, Florida State University, and Professor

[28] The discussion in this subsection is based on a detailed description of procedures provided by Professor David Ling of the University of Florida and Professor Dean Gatzlaff of Florida State University who prepared the repeat sale price indexes.

David Ling, Department of Finance and Real Estate, School of Business, University of Florida. The techniques used are similar to those described in their recent papers, see for example Gatzlaff and Ling (1992). The process can be broken down into ten discrete steps as follows.

1. Acquisition of property tax data from the Florida Department of Revenue for Dade County (Miami), Duval County (Jacksonville), and Pinellas County (St. Petersburg). Data are collected for each parcel of land and maintained by the local property tax appraiser's office for use in updating annual appraisals of assessed property values. The data record for each parcel includes: land use code, assessed value of real property, assessed land value, most recent sales price and closing date, second most recent sales price and closing date, owner's address and homestead status, and several other property-specific variables.

2. Identification and selection of single-family detached housing units first by land use code and homestead status. Multi-family sales prices are determined by factors such as rental status, vacancy rate, and terms of sale which make their incorporation in a repeat sale index difficult.

3. Clean the data to remove possible outliers and cases where only one sale was observed. Cases of sales for $1, living area below 800 square feet and above 6,000 square feet, lot size below 1,500 square feet and above 5 acres, and/or lacking information on year built were deleted. It is necessary to make a judgement, based on sample size, of the time period that can be covered by the index. Because the data set only contains the previous two transactions, the number of transactions available for years before 1980 declines quickly. Based on the number of transactions available, it was necessary to drop observations in which the first transaction occurred before January 1971. This left data sets with 43,898 (Dade), 20,315 (Duval) and 50,258 (Pinellas) observations for the three counties.

4. Identify the latitude/longitude and census tract for street address within each county.

5. Match-merge the cleaned repeat sale property transactions data from step (3) with the latitude/longitude file developed in step (4). The geocoded observations then have latitude/longitude and census tract information appended. Match rates (resulting sample sizes) were 97.7% (42,729), 92.4% (18,778), and 92.6% (46,528) for Dade, Duval, and Pinellas counties, respectively.

6. Geocode the shoreline location for each county.

7. Develop an algorithm to compute the minimum distance to the shoreline from geocoded observations within each county.

8. Match-merge the shoreline distance values from (7) to the cleaned, geocoded repeat sale data set from (5) and append distance to shoreline in feet to the data record for each property.

9. Using ordinary least squares techniques, estimate a modified repeat-sale regression model of house prices for each of the three counties over the January 1971- December 1992 period. The key modification to normal procedures was to estimate the model of house prices allowing distance from the shoreline to be a partial determinant of price.

10. Given the estimates in (9), house price indexes and rates of change in those indexes can be computed for various distances from the shoreline in each of the three counties over the January 1971 to December 1991 period. Specifically, indexes were constructed for housing units located (1) at the shoreline, (2) one mile from the shoreline, (3) inland areas five miles from the coast.

Following Bailey, Muth and Nourse (1963) and the extended subsequent literature, estimation of a repeat sales price index is based on a the assumption that the sales price of property i, $price_{2i}$ which is sold for a second time at time $\mathbf{T_{2i}}$ can be expressed as a function of the initial sales price, $price_{1i}$, and the time of initial sale, $\mathbf{T_{1i}}$, by first assuming that $\mathbf{price_{2i} = price_{1i}(1 + r_1)^{D1i}(1 + r_2)^{D2i}(1 + r_3)^{D3i}...(1 + r_n)^{Dni}}$ where r_t is an index of cumulative appreciation through period t, and $\mathbf{D_t}$ is an exponent equal to **-1 if period** $\mathbf{t = T_{1i}}$**, equal to +1 if** $\mathbf{t = T_{2i}}$, and equal to 0 for all other values of **t**. Dividing through this equation by $\mathbf{price_{1i}}$ and taking the natural logarithm of both sides yields an expression for the sales price ratio: $\mathbf{LN(price_{2i}/price_{1i}) = D_{1i}\,LN(1 + r_1) + D_{2i}\,LN(1 + r_2) + ... + D_{ni}\,LN(1 + r_n)}$. Given that the sales prices and dates can be observed for each property, it is possible to estimate: $\mathbf{LN(price_{2i}/price_{1i}) = \beta_1 D_{1i} + \beta_2 D_{2i} + ... + \beta_n D_{ni} + \epsilon_i}$ where ϵ_i is an identically and independently distributed normal random variable, the β's are parameters to be estimated which reflect the compound appreciation between period 1 and subsequent periods, and the **D's** are as defined above.

The conventional repeat sale estimation procedure was modified given the special needs of this research for estimates of appreciation effects in beachfront areas. The modified approach to estimation of a repeat sale price index considers distance from the coast as a determinant of housing prices. The relation between distance to the coast and housing prices is complicated by the possibility that prices first fall with distance and then rise again with distance as one approaches inland urbanized areas. This is particularly likely for the three counties chosen here because, in each case, a large urban area is located inland from the coast, specifically, the sample includes Dade County (Miami), Duval County (Jacksonville), and Pinellas County (St. Petersburg). Indeed, the housing markets in all these beachfront areas are influenced by urban sprawl from the large cities and many beachfront residents are commuters who work in the city. In order to insure sufficient property transactions to estimate a repeat sale price index, it was necessary to sample beachfront areas that were part of larger urbanized areas. Strip development along the shoreline of an isolated beach community could not produce the number of property transactions needed to produce a repeat sale price index over the 20+ year period required for this study.

The general equation estimated using ordinary least squares techniques has the form:

$$\mathbf{LN(price_{2i}/price_{1i}) = \beta_1 D_{1i} + \beta_2 D_{2i} + ... + \beta_n D_{ni} + [\gamma_1 D_{1i} + \gamma_2 D_{2i} + ... + {}_n D_{ni}]*ln(DIST) + \gamma_{0.5} shore_{0.5}*ln(DIST) + \epsilon_i}$$

where: **LN(price2/price1), the D's and β's are as defined above,**

shore is a dummy variable equal to 1 if distance to the shore is > 0.5 miles and 0 otherwise,

ln(DIST) is the logarithm of distance to the shoreline,

and the γ's are parameters to be estimated reflecting the effect of distance on the housing price index for properties located less than 0.5 miles from the coast.

This functional form allows the relation between distance to the coast and the price index to be different within a half mile of the coast than it is as property location moves further inland.

COMPUTING THE REPEAT SALE HOUSE PRICE INDEX

Estimates of the repeat sale house price index discussed above are computed by substituting various specific distances into the estimated function along with two time periods, the base year of 1971 and the alternative year for which the index is being computed. For simplicity, the index was computed at three specific distances, **DIST = 0** (the beachfront location), **DIST = 1.0** (the one mile off-coast location), and **DIST** = the mean value of **DIST** in the sample (the inland location). Specifically, the value of the index at time **T** in area **i**, at distance **DIST = 0** (the shoreline), $\mathbf{INDEX_{Ti}}$, would be computed as:

$$\mathbf{INDEX_{Ti} = EXP\ [-\beta_{1i} + \beta_{Ti} + (-\gamma_{1i} + \gamma_{Ti})\ LN(0)) + \gamma_{0.5}\ LN(0)}.$$

Note that, because distance = 0, the $shore_{0.5}$ dummy variable equals 1.0. The value of the index can be computed for each year, for each of the three locations in each of the three counties.

Figures 11, 12, and 13 show the pattern of house price indexes for each of the three counties over the 1972 to 1991 period. All indexes have been normalized so that the inland price index in 1972 equals 1.0. Overall, the computed price indexes follow a similar pattern that agrees well with expectations. In all cases, the 1972 value of the index at the inland location is highest and the index for the beachfront is lowest. Similarly, for all three counties, the rate of price appreciation for the beachfront area is highest so that the price index is uniformly highest for the beachfront area by 1991. Figures 14, 15, and 16 display changes in the house price index at the three locations in the three counties over the 1972 to 1990 period. The rate of appreciation in the price index for beachfront areas often differs significantly from that of either the off-coast or inland areas. There is a high variation in the rate of change in house prices over the period, including periods of very rapid appreciation and even some periods when prices fell slightly. It appears that the beachfront real estate market is subject to some influences that do not characterize either off-coast or inland areas. This raises the possibility that differences in rates of appreciation could be due to shore protection efforts.

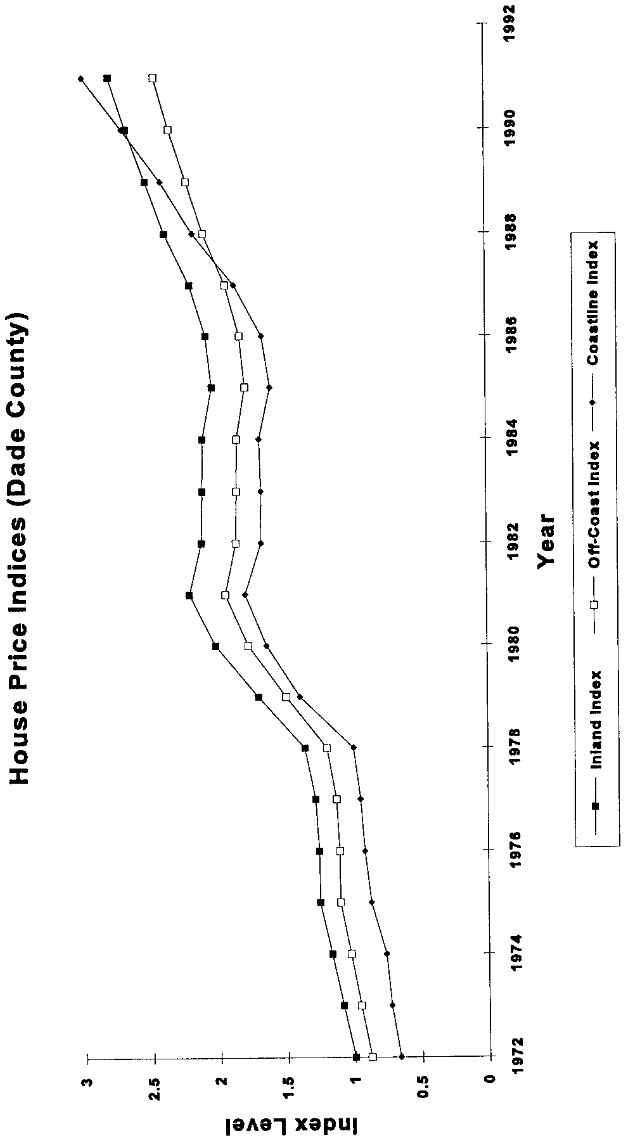

House Price Indices (Dade County)
Index Level
3
2.5
2
1.5
1
0.5
0
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
Year
Inland Index
Off-Coast Index
Coastline Index

Figure 11

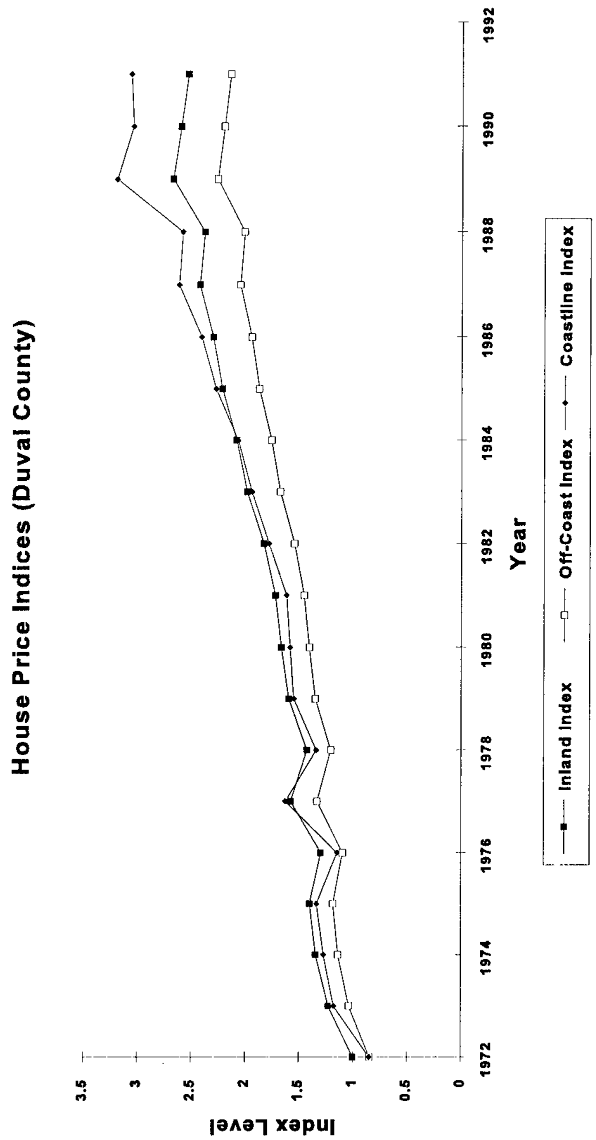

House Price Indices (Duval County)
Index Level
3.5
3
2.5
2
1.5
1
0.5
0
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
Year
Inland Index
Off-Coast Index
Coastline Index

Figure 12

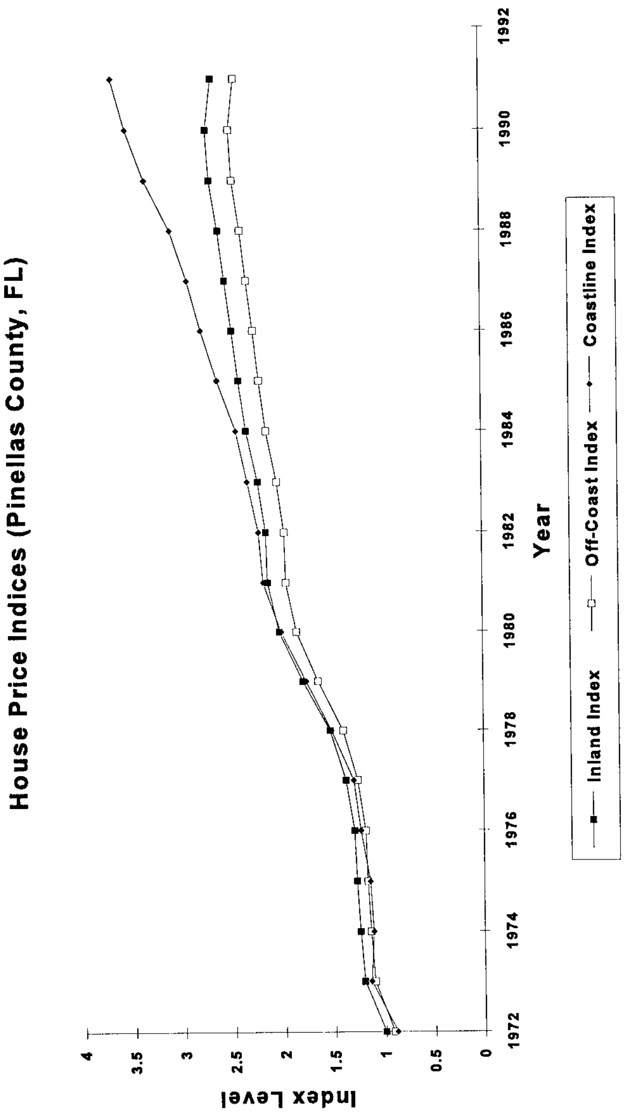

House Price Indices (Pinellas County, FL)
Index Level
4
3.5
3
2.5
2
1.5
1
0.5
0
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
Year
Inland Index
Off-Coast Index
Coastline Index

Figure 13

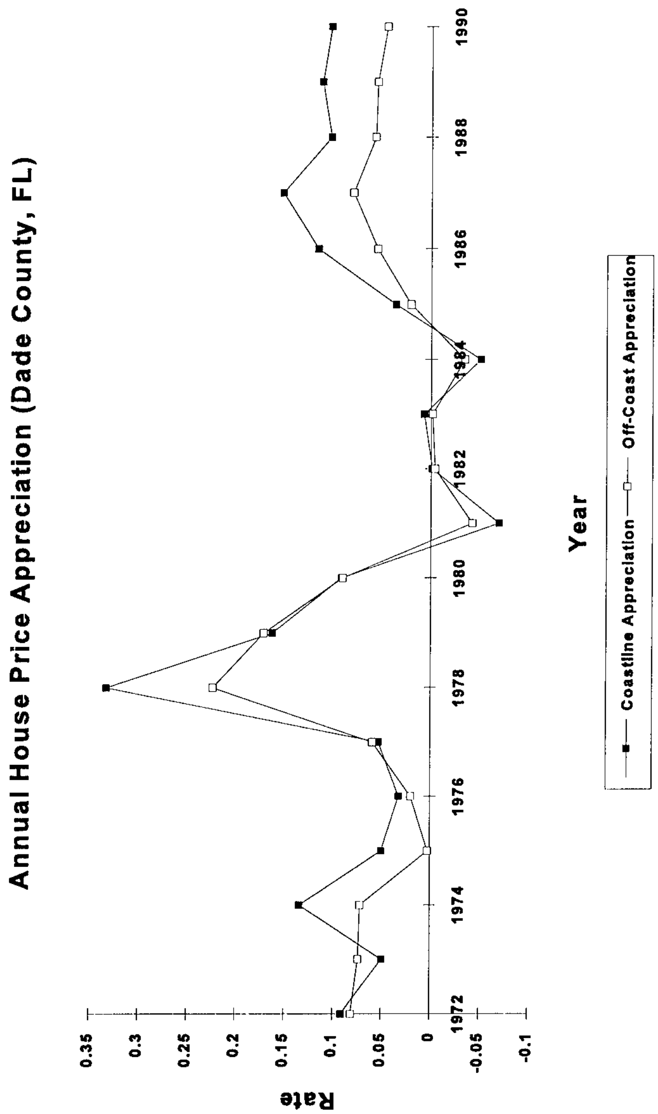

Annual House Price Appreciation (Dade County, FL)
Rate
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
Year
Coastline Appreciation
Off-Coast Appreciation

Figure 14

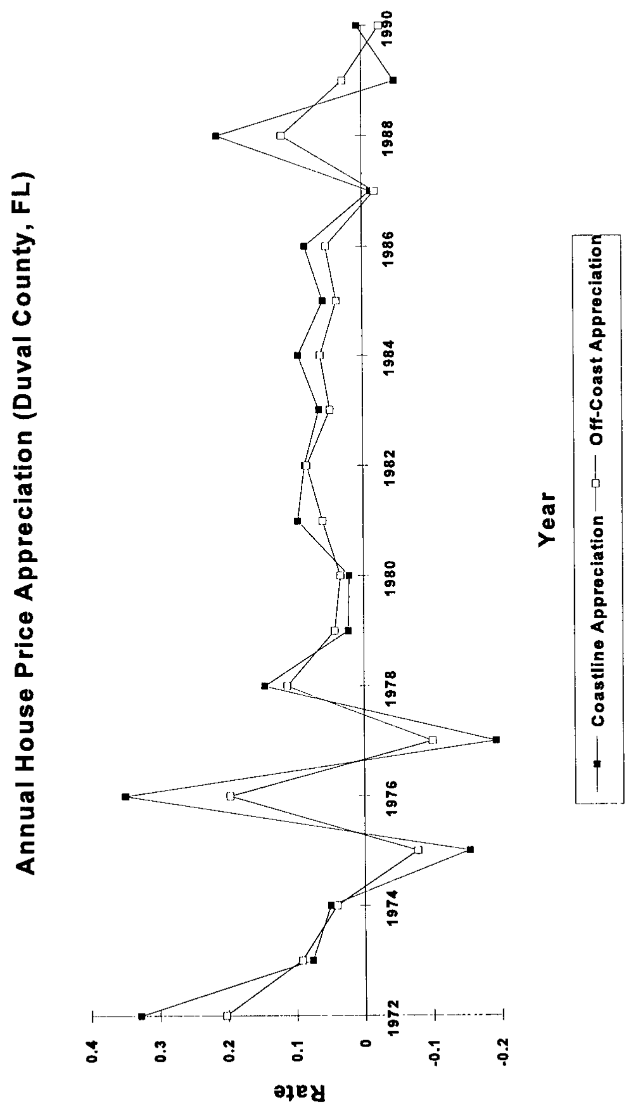

Annual House Price Appreciation (Duval County, FL)
Rate
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Year
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
Coastline Appreciation
Off-Coast Appreciation

Figure 15

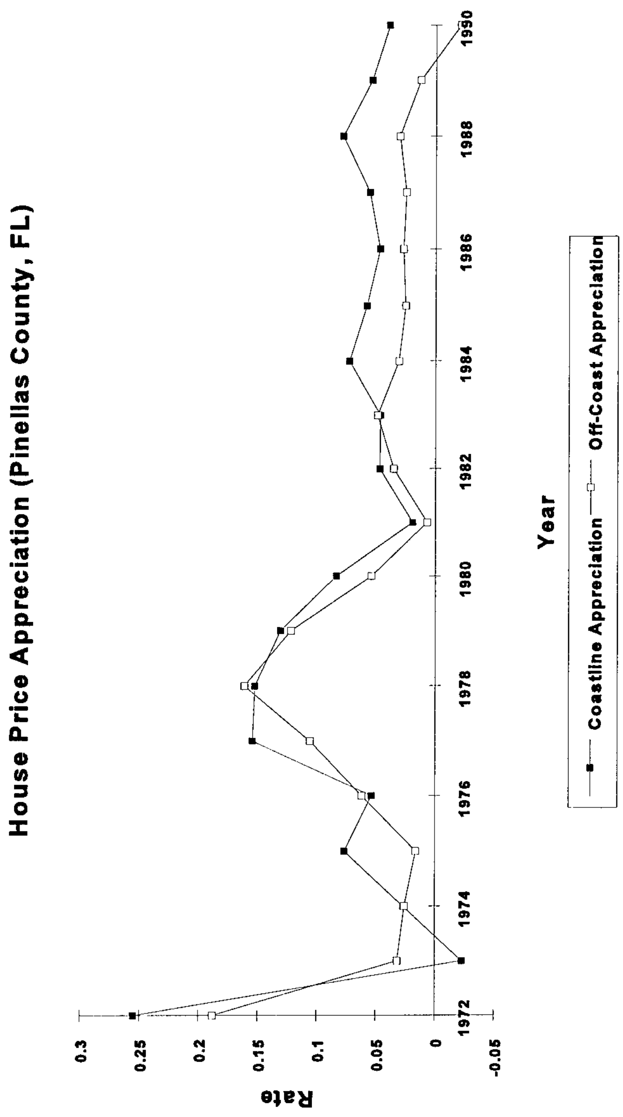

House Price Appreciation (Pinellas County, FL)
Rate
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
Year
Coastline Appreciation
Off-Coast Appreciation

Figure 16

ESTIMATING HOUSE PRICE CHANGE AND SHORE PROTECTION

Given that, by the 1990s, the housing price index in all three counties is higher on the beachfront than inland, it is not surprising that these areas have significant rates of investment in beachfront residential real estate. Market prices are clearly directing development to beachfront areas of all three counties. The estimates reported here are an attempt to determine the extent to which more rapid rates of beachfront price appreciation are determined by Corps shoreline protection activities.

The Corps has been authorized to act on the shorelines of all three counties since the 1960s. There was insufficient data to extend the repeat sale price index to that period. Hence the estimates are designed to determine effects of actual Corps activity rather than the initial authorization. For all three counties, there was a significant gap between initial authorization and actual physical Corps activity so that the initiation of Corps projects falls within the period covered by the house price index for all areas.

The basic estimating equation takes the following form:

$$\mathbf{Coast} = \alpha_0 + \alpha_1\mathbf{Inland} + \alpha_2\mathbf{Active} + \alpha_3\mathbf{Tcost} + \alpha_4\mathbf{Storm} + \beta_1\mathbf{Dade} + \beta_2\mathbf{Duval} + \epsilon$$

where: **Coast is annual percentage change in estimated house prices at the shoreline,**

Inland is the estimate of annual percentage for inland areas,

Active is a dummy variable equal to unity during the period after the Corps project became active and zero otherwise,

Tcost is the annual dollar expenditure,

Storm is a variable supplied by the Corps indicating the presence of storms damage in each year,

Dade and Duval are dummy variables for those two counties, and

ϵ **is an identically and independently distributed random error term.**

The average beachfront appreciation rate was 12%, with a substantial standard deviation of 22% including some years in which the rate of change in housing prices was as low as -19%. Table 3 presents estimation results for a series of equations in which Coast is the dependent variable. The first equation estimated in Table 3 shows that beachfront appreciation is largely a function of inland appreciation, that is changes on the coast reflect inland economic growth. There are no significant differences in the relation between beachfront appreciation and inland appreciation associated with location in Duval or Dade counties, as opposed to Pinellas. Given that the distances between beachfront and inland real estate have been standardized to be the same for all three areas, this result is not surprising.

Adding the two variables reflecting the presence and level of Corps activity, Active and Tcost, and the Storm variable indicating significant storms, adds essentially nothing to the predictive power of the model. These variables are added sequentially in a series of estimates reported in the bottom part of Table 3. While estimated coefficients Active and Tcost generally have the expected positive sign, they are always non-significant. Similarly, the estimated coefficient of Storm is a negative and non-significant. Even if the estimated coefficients of all three variables were statistically significant, their combined effect on the rate of beachfront housing price appreciation would be modest compared to the average rate of appreciation of beachfront real estate. The failure to have a single hurricane strength storm hit any of the three counties during the 1971-1992 sample period limited the opportunity to observe effects of a major storm in the data. However, Corps activity on these beaches was not trivial during this period and yet there is no significant effect observable on the differential between price appreciation in inland and beachfront areas due to this activity.

The results presented here for beachfront housing price appreciation are consistent with the findings from the more general econometric model of real estate development in beachfront communities. There is a growing demand for beachfront real estate based on economic growth which is occurring inland. Corps activity follows development, it is not a significant cause of development.

TABLE 3 - Determinants of Beachfront Housing Price Change

Model 1: Effect of Inland Price Change

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
Coast					11.97733
Inland	1.011864*	.025829	39.176	0.000	9.853667
Constant	2.006762*	.6086612	3.297	0.002	1
Number of obs = 60		F(1, 58) = 1534.72		Prob > F = 0.0000	
R-square = 0.9636		Adj. R-square = 0.9630		Root MSE = 4.2827	

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
Coast					11.97733
Dade	.2002201	1.375675	0.146	0.885	.3333333
Duval	-.4220977	1.375686	-0.307	0.760	.3333333
Inland	1.011752*	.0262374	38.561	0.000	9.853667
Constant	2.081825*	1.006728	2.068	0.043	1
Number of obs = 60		F(3, 56) = 495.89		Prob > F = 0.0000	
R-square = 0.9637		Adj. R-square = 0.9618		Root MSE = 4.3502	

Model 2: Add Effects of Corps Activity and Storms

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
Coast					11.97733
Dade	-.2591782	1.472525	-0.176	0.861	.3333333
Duval	-.2263416	1.395904	-0.162	0.872	.3333333
Inland	1.06282*	.0270023	37.266	0.000	9.853667
Active	1.315599	1.484134	0.886	0.379	.2666667
Constant	1.872782*	1.035859	1.808	0.076	1
Number of obs = 60		F(4, 55) = 370.69		Prob > F = 0.0000	
R-square = 0.9642		Adj. R-square = 0.9616		Root MSE = 4.3586	

* - indicates that the estimated coefficient is statistically significant at the 90% confidence level.

TABLE 3 - Determinants of Beachfront Housing Price Change

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
Coast					11.97733
Dade	-.3957683	1.552963	-0.255	0.800	.3333333
Duval	-.3089655	1.434234	-0.215	0.830	.3333333
Inland	1.008507*	.0282189	35.739	0.000	9.853667
Active	.912123	2.011203	0.454	0.562	.2666667
Tcost	.0000353	.0001176	0.300	0.765	3146.767
Constant	1.920372*	1.056488	1.818	0.075	1
Number of obs = 60		F(5, 54) = 291.66		Prob > F = 0.0000	
R-square = 0.9643		Adj. R-square = 0.9610		Root MSE = 4.3951	
Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
Coast					11.97733
Dade	-.4603655	1.557026	-0.296	0.769	.3333333
Duval	-.4009376	1.440037	-0.278	0.782	.3333333
Inland	1.010759*	0.283721	35.625	0.000	9.853667
Active	.5306881	2.057417	0.258	0.797	.2666667
Tcost	.0000903	.0001324	0.682	0.498	3146.767
Storm	-2.341485	2.569889	-0.911	0.366	.0333333
Constant	1.957012*	1.058918	1.848	0.070	1
Number of obs = 60		F(6, 53) = 242.43		Prob > F = 0.0000	
R-square = 0.9648		Adj. R-square = 0.9609		Root MSE = 4.402	

* - indicates that the estimated coefficient is statistically significant at the 90% confidence level.

SECTION VI
INDUCED DEVELOPMENT: FINDINGS AND RECOMMENDATIONS

Theoretical analysis has demonstrated that shore protection projects have the potential to generate several distinct types of induced development including additional development that increases total beach development, relocated development that moves development closer to the shore from more protected inland locations, and relocated development that moves development from unprotected beachfront areas to the newly protected area. Any conclusions regarding the overall effects of induced development on changes in expected future storm damage or beach environment would require separation of total induced development into these three components. If induced development relocated from alternative unprotected beachfront areas is significant, then development is likely moving from areas where expected damage is high to those where it is low. This type of relocated development results in a "bonus" of extra reduction in expected damage beyond that which would be calculated based on the initial level of development in the protected area. Also, this type of relocated development may have important implications for environmental conditions at both the protected and the unprotected beach.

Regardless of its magnitude or composition, induced development is not a problem or extra social cost as critics of shore protection appear to suggest. Any public project which enhances safety in a particular area should result in an induced development effect. Furthermore, this induced development is a positive rather than a negative result. For example, harbor protection projects should lead to additional docking in the harbor by ships and boats - i.e. "induced boat docking" which includes the boats relocated from less protected harbors and some additional boats. If a major storm hits the protected harbor, some of the damage will accrue to these induced boats. Is this an extra cost which should be charged against harbor protection projects? Clearly, the induced boat docking results from a voluntary relocation from areas where the benefits of docking are lower (perhaps because expected damage is higher) to the protected harbor, as well as some additional boat docking resulting from a reallocation of resources away from other less productive uses. If the initial protection project could be justified based on benefit/cost analysis excluding induced boat docking, then voluntary induced docking, whether additional or relocated, can only add to the net benefits of the project, not subtract from them. The same line of argument holds for provision of lighthouses, lighted walkways, police stations, fire houses, etc. Adding a street light in a dark crime-ridden area should attract induced pedestrian traffic and some of those attracted by the light may be crime victims. But this cannot be used as an argument against providing the light.

The fallacy in the argument that induced beachfront development reflects an additional cost should be obvious from these simple examples. The extended theoretical analysis in Section II makes this argument rigorously and leads to the following findings:

1) Benefit/Cost procedures as currently described in the *National Economic Development Procedures Manual: Coastal Storm Damage And Erosion* (1991) provide appropriate, indeed conservative, guidance regarding the criteria for undertaking projects. Projects identified as having a benefit/cost ratio greater than one using these procedures should be considered for funding. No special or additional consideration of costs associated with possible future damage of induced development is appropriate as part of a proper benefit/cost analysis.

Indeed, if Corps projects are producing a large effect on expected storm damage, then significant amounts of induced development may result.

2) The economic effects of shore protection projects differ from other flood protection activities in that it is likely that shore protection lowers the ultimate price of beachfront recreation services, where recreation is broadly defined to include the many aspects that make shore location attractive. This fall in price of recreation services means that some benefits of the project are passed forward to the general public engaging in a variety of beachfront activities.

3) The induced development which is relocated from other beachfront areas provides an opportunity to manage beachfront development. Current CBRA restrictions on government actions reflect a concern about the location of development along the coastline. However, these restrictions are entirely negative in character and have the effect of encouraging completely private beachfront development that excludes the general public. Shore protection offers a positive incentive to relocate development in ways that serve a public purpose, including preservation of the right of easy public access.

EMPIRICAL FINDINGS REGARDING INDUCED DEVELOPMENT

Empirical research on induced development in coastline areas included a survey of residents and two very different econometric studies of beachfront development. Given the time constraints on this study, these three empirical studies were undertaken simultaneously and independently. In spite of this lack of coordination, the overall findings of these efforts are remarkably consistent and can be presented as a single set of conclusions.

1) The primary determinant of development in beachfront communities is growth in demand based on rising income and employment in inland areas. Changes in inland economic activity dominate statistical models of changing numbers of building permits and residential real estate prices in beachfront areas. Areas receiving Corps project approval tend to be growing very fast but that growth generally began before the project approval date. Indeed prior growth is necessary to justify Corps activity.

2) Various indicators of the presence and/or level of Corps activity in beachfront communities, including: tons of sand, total expenditure, initial authorization for a project, total expenditure per year, modification of the Corps agreement, and dates of Corps involvement, generally have no statistically significant relation to development in those areas. There is some indication that initial approval of a site for Corps activity has a small, positive and significant relation to development but a variety of other indicators of Corps involvement had no significant effects in a number of alternative models. Thus, the statistical evidence indicates that the effect of the Corps on induced development is, at most, tiny compared to the general forces of economic growth which are stimulating development in these areas.

3) Residents of beachfront communities are generally not aware of the nature of Corps projects and are just as likely to mention the Corps as a solution to storm damage and erosion problems in areas where the Corps is not active as they are in areas where the Corps is active. Length of residence appears to increase perception of erosion problems and of the Corps, but higher income owners are less likely to mention Corps intervention as a solution. Taken together, these findings suggest that Corps projects have little, if any,

induced development effects. It appears that Corps activity has little effect on the decisions of developers, homeowners, or housing investors. These results are supported by two additional pieces of informal evidence. First, the General Accounting Office (1982) and (1988) studies of effects of the National Flood Insurance program concluded, based on interviews with real estate professionals, that the incentives for coastline development were strong and that the influence of government programs which lower risk was marginal. Second, in the course of performing the research reported here, a number of informal interviews were conducted with real estate agents and developers who are active in the beachfront communities which were analyzed. Based on these conversations, real estate professionals are generally unaware of the beachfront areas which have been approved for Corps projects. Furthermore, they regard payments for flood insurance as a minor consideration in making real estate development decisions.

There are many possible reasons for this lack of effect found in the formal empirical tests or in informal surveys. It may be that recent buyers of real estate in beachfront communities are not aware of Corps activity or do not perceive it as an important factor in lowering the risk of flooding or erosion problems. Perhaps they believe that state and local governments will protect developed beach areas without Corps involvement. There is direct evidence that wealthy homeowners prefer local or private efforts at protection because of the requirements for public access that accompany Corps protection projects. Given that the subsidy component of the National Flood Insurance program has been essentially eliminated for recently constructed units, homeowners face insurance prices that signal the possibility of direct flood damage. Perhaps these payments are not large enough to have an important effect on development. It is not clear that the threat of damage to nearby beachfront areas is correctly perceived. Thus, there may be problems of inadequate information regarding risks of investing in beachfront real estate.

RECOMMENDATIONS AND ADDITIONAL OBSERVATIONS

The task of this study was to determine the empirical importance of induced development, with the implicit assumption that induced development must somehow be a bad thing. Within the context of a complete economic model of the market for beachfront residential development it is evident that induced development is not bad at all. Given that growth of income and employment inland is driving coastline development, the question is not whether or not that development will take place but rather how concentrated it will be. Is it better to have the entire coastline developed at moderate density or to have development concentrated in some areas leaving others relatively undeveloped?

Selective shore protection could potentially be used to encourage diversity in the density of development. Relocated development could move economic activity from more vulnerable beach areas to protected areas. The problem with such a strategy is that, given induced development effects are small, relocated development effects are also small. In addition, further research would be needed to determine the pattern of relocation across beach areas.

One possible explanation for the finding of small induced development effects is that other policies and activities, such as building highways, bridges, and sewer systems, are likely to have far larger induced development effects and yet do not face the detailed benefit/cost computation or intensive economic analysis required for approval of a Corps project. Given that the amounts spent for these infrastructure projects are far larger than the Corps shore protection budget and the fact that they may impact upon relatively undeveloped areas that would be denied Corps protection, their effects on the spatial pattern of development may be correspondingly larger. If a comprehensive plan for encouraging selective coastline development is to be developed, the effects of all public sector actions on relocated development must be modeled and estimated empirically. This study is, at most, a small first step in such an effort to understand the relation between public sector expenditures and the spatial pattern of coastline development.

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13. ABSTRACT *(Maximum 200 words)*

The purpose of this report is to present an assessment of the relation between Federal shore protection projects and potential induced development in coastal areas. The economic analysis proceeds from the construction of a general theoretical model. Following from the theory, three independent empirical tests for the relation between shore protection and actual local economic development are implemented. This was conducted to fill a major gap in our understanding of the effects that Federally sponsored infrastructure projects may have on the dynamics of local growth and development.

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