Costs of Coastal Hazards: Evidence from the Property Market

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Abstract

A hedonic price model suggests that flooding and erosion hazards, and the actions taken against them, are major determinants of property values in American coastal areas. A zoning ordnance against new construction within the 60-year erosion hazard area would increase property values and perhaps conserve the coastal ecosystem.

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Introduction

The problem of shoreline erosion is a major concern among property owners and those involved in coastal management. Eighty to 90 percent of the sandy beaches in the United States are receding (Leatherman, 1993). In these areas the gradual disappearance of land into the water has reduced the distance separating building from flood waters and waves, so the buildings have become more vulnerable to storm damages. Population growth and substantial development has increased the potential of a major disaster from the cumulative effects of eroded beaches, hurricane force winds and coastal flooding (Dean, 1999).

In managing erosion there are three broad alternatives: (1) constructing coastal armoring, especially groins and seawalls (2), replenishing a beach with more sand, and (3) relocating threatened property improvements and permitting nature to take its course. The relative desirability of each erosion management alternative has been the subject of controversy between engineers (who prefer alternatives (1) and (2)) and coastal geologists (who prefer alternative (3)). The position of coastal geologists is summarized in Pilkey, et al. (1982), while the opinion of engineers is summarized in O'Brien (1982). The debate has also appeared in the popular press, eg. Kemper (1992). The key element in this debate is not over protecting property but rather the unintended ecosystem and recreational impacts of alternatives (1) and (2). Geologists argue that only a relocation policy can preserve the coastal environment in a natural state, and the other alternatives are unsustainable. Engineers claim that little evidence links beach destruction from beach nourishment or armoring, but geologists counter with the fact that attractive recreational beaches are not observed to coexist with man-made erosion control.

In coastal communities, the typical reaction to erosion has been to first protect property by armoring the shore. This is very understandable because installing rip-rap is something that an individual property owner can do to protect his property in the short run. Over time, however, other waterfront property owners respond in a similar way to larger threats, and today some entire communities are armored with very substantial seawalls, usually financed by public funds. This pattern of protection is indicative of a policy process that responds well to property owners' concerns about potential losses. However, the process is less responsive to the needs of tourists, day-trippers and vacationers whose primary interest is beach amenities, whether recreational or ecosystem.

This paper addresses the problem of how property values change when beach amenities are degraded. While traveling in America’s coastal areas one can observe that the better beaches support substantial tourist economies. However, as a beach becomes less attractive, lower tourism levels will lead to lower demand for land as business operators experience less demand for their rental cottages, restaurants, shell shops, etc. Using a hedonic price model for coastal properties, the structural differences between two types of real estate markets are estimated: good beach versus ordinary beach communities. We hope that this will demonstrate, in terms of property values, what a community may loose if its beach becomes degraded.

The Role of Coastal Risks and Amenities in a Property Market

Within a hedonic price model it can be shown that for the utility maximizing buyer, the marginal implicit price of a characteristic is equal to the buyer’s marginal willingness to pay for that characteristic (see, eg., Freeman, 1993). For coastal property, the relevant characteristics include the usual structural qualities plus the distance to the water, the width of the beach, etc. When the characteristic being valued involves something that can alter the risk of a property loss, then the interpretation of marginal implicit price becomes more interesting. Examples of this include the characteristics that indicate the house is more prone to erosion and/or flooding damage.

In a 1985 article, Kerry Smith has shown that the marginal implicit price of a risk-reducing characteristic (denoted MIP_p for the characteristic *p*) is equal to the buyer's marginal willingness to pay for a reduction in risk, which is the marginal option price. When the buyer can purchase formal insurance against the loss then the model used by MacDonald, et al. applies. They show that if the National Flood Insurance Program (NFIP) compensates perfectly for a loss, then MIP_p should equal the capitalized value of the change in the insurance premium that the change in *p* has caused. However, if NFIP under-compensates for a loss, then the buyer would desire more *p* so he could protect himself against this monetary loss. In this case, the MIP_p would reflect both the marginal option price and the capitalized change in the insurance premium that the change in *p* has caused.

For coastal properties, both flooding and erosion risks must be considered. A lower rate of shoreline recession probably has an positive effect on property values. This is because many buyers will be aware of erosion hazards, both from the increased flooding risk and from the risk of house collapse. Buyers' awareness is due to the fact that erosion and the problems it causes have been reported in the news media. To gather property-specific erosion information the prospective buyer can consult a number of authorities. Also, rapid recession leaves tell-tale clues such as dune scarping, toppled trees, and other signs that indicate the property is at risk from erosion damage.

Furthermore, it is likely that buyers will tolerate some erosion if risk to the property is buffered by a sufficiently large distance between the property and the water. Assuming that buyers are indifferent between the source of their erosion protection, these two risk-reducing effects can be combined into one variable, called *Geotime*. *Geotime* is defined as the expected number of years until the setback distance is zero, given the property's historical erosion rate. For example, consider a property which had a setback of 200 feet when purchased. If the historical erosion rate is 4 feet per year, then *Geotime* is equal to 50 years until setback is zero, *ceteris paribus*. This measure of erosion risk is used in this study.

Earlier research by Kriesel, Randall and Lichtkoppler (1993) for the Ohio part of Lake Erie has indicated that *Geotime* alone produces a very sharp decrease in price for values under ten years. Buyers probably do not wait until the last few years of a property's life before they begin to discount their bid prices. To add more flexibility to the model the square of *Geotime* was added to the model. The same approach is used in this research. Thus, the functional form used is:

$$\ln \textit{Property Price} = \beta_1 + \beta_2 \ln \textit{Geotime} + \beta_3 (\ln \text{Geotime})^2 + \ldots + \beta_k X_k$$

where ln indicates the natural logarithm of a variable, β_j is the regression coefficient and the other variables X_i are entered in either logged or raw form, as indicated in the list of variable definitions in Table 1.

Buyers are aware of their risk of suffering a capital loss by flooding. They can purchase a house that is built on land or piles elevated above potential flood waters or they can purchase flood insurance. Buyers who are more risk averse may purchase both types of protection. Similarly, buyers who feel that flood insurance coverage may not fully compensate them for a loss (whether by coverage limitations or errors by the adjuster) would also buy both kinds of protection. All susceptible properties in the sampling for this study have the opportunity to buy flood insurance, except those in Coastal Barrier Resources Act (CBRA) areas since 1983, and we account for these with a dummy variable. We then measure the remaining protection with the variable *Elevation*, given as the feet that the first floor is elevated above the base flood elevation. If buyers are more risk averse or if they suspect incomplete compensation, then this variable should have a positive effect on price.

Buyers can also reduce risk of loss if they purchase a house that has been constructed under FEMA's mandated building codes. *Built Post-FIRM* is a dummy variable that provides a measure of a given structure's resistance to flood damage since it is '1' if the house was constructed after the community's acceptance into the Regular insurance program, when the tougher code was in effect. Davison (1993) claims that most of the reductions in flooding losses has occurred because of the higher building standards, so houses built under these standards should be more valuable and the beta estimate for *Built Post-FIRM* should have a positive sign. This and the other variables for the hedonic model are described in Table 1.

The *Sold Post-FIRM* variable is set to equal one if the home was sold after issuance of the Flood Insurance Rate Map. The delineation of FIRMs, to the extent that they provided new, unexpected, and believable information about risk, could have affected home prices. For some properties, the information in the FIRMs would have been good news if it indicated that they were not in a flood zone, and it would have increased their price. However, for most coastal properties delineation of FIRMs probably had the opposite effect. Therefore, we expect that the *Sold Post-FIRM* variable will have a negative influence in the hedonic. If the *Sold Post-FIRM* variable is negative, it should be interpreted as evidence that "notification of erosion hazard status" is new and useful information to home buyers who then react to the information about the risk by decreasing their bid prices. Given some reasonable assumptions, this estimated parameter should give an approximation of the property market's reaction to FEMA's future delineation and notification of erosion hazard zones.

The *CBRA* variable equals 1 if the house was constructed since 1983 and it is located in a CBRA area, and it is 0 otherwise. Properties in CBRA areas are inelgible for flood insurance and other federal aid. Can the coefficient of this dummy variable be expected to yield the effects of denying flood insurance? That depends on whether the lack of insurance is the only major distinction between these areas and other areas. According to experts, the CBRA areas were designated in the 1980's precisely because they were undeveloped, wild areas and have largely remained so since then. They continue to lack water, sewer and other utilities that would make them valuable property. Therefore, the coefficient of this dummy will serve as an upper bound on what the true effect of denying insurance may be.

We think that *Geotime*, *Elevation*, *Insurance Price* and *Sold Post-FIRM* are our best available indicators of flooding and erosion risk. There are other factors that also affect risk, such as the setback distance, beach width, beach nourishment and erosion protective devices. However, these factors also affect the property's amenity value and any econometric modeling must account for this feature. For example, consider the setback distance between the structure and the erosion reference feature, defined as the variable *Distance to ERF*. Greater *Distance to ERF* reduces risk of storm damage, thereby increasing the property's value, but greater *Distance to ERF* also reduces the ocean view and beach access, thereby decreasing the property's value. At first blush, one does not know whether a variable like *Distance to ERF* should have a positive or negative effect in the hedonic equation. In a hedonic with a simple linear functional form, if buyers valued the risk-reduction feature of *Distance to ERF* more than its amenity feature, then *Distance to ERF* would have a positive effect.

It is possible that the price curve would have a sort of bell shape. If the hedonic also contained a dummy variable for waterfront property, then price could be lowest at the beach. Houses slightly inland would increase in price in response to the risk-reducing feature of *Distance to ERF*, but only up to some point because they would out of the hazard zone. At some point there would be a price peak and prices would thereafter decline as the amenity value is lost. This unusual nonlinearity in the price gradient would require a hedonic equation with a specialized functional form.

To clarify the direction of influence that variables such as *Distance to ERF* should have in the hedonic, and whether an unusual functional form is required, consider the following. Imagine two properties identical in every aspect (including the erosion rate) except for *Distance to ERF*. The calculated value of *Geotime* will be higher for the property that has the most *Distance to ERF*. When these two properties are included in a hedonic which regresses *Property Price* upon *Distance to ERF* and *Geotime*, the coefficient for *Distance to ERF* will include its impact on price as an amenity characteristic only. This is because *Distance to ERF*'s impact as a risk characteristic will have been reflected in a higher value of *Geotime*, and the resulting risk reduction will be captured by the *Geotime* coefficient. Therefore, a hedonic which includes both variables should yield a positive sign on *Geotime*'s regression coefficient and an unambiguous negative sign on *Distance to ERF*'s coefficient. Furthermore, the problem of discovering a specialized functional form is moot.

A similar result to *Geotime* and *Distance to ERF* would apply to factors which unambiguously change the risk that is reflected in the values of other variables in the model.

Beach width is one of these factors because a wider beach reduces wave action. Since wave action is used when FEMA calculates a property's base flood elevation, a reduction in wave action will unambiguously increase our measure of flood risk, *Elevation*. Therefore, the variable *Beach Width*, is included as a measure of beach quality, not flood risk, which should have a positive impact on property values.

The effect of erosion protective devices is more ambiguous than the others. We defined the dummy variable *Armor* that is 1 if the property is waterfront and its shore has hard stabilization and zero otherwise. Data for this variable is obtained in the mail questionnaire, in the section where the owner could indicate that, at the time of purchase, the nearest beach had a seawall, rip-rap, groins or a breakwater.

These protective devices reduce the risk of erosion and flooding (a positive effect on price), but their design characteristics are usually visually unattractive (a negative effect). However, to the extent that the device decreases wave action and thereby decreases the property's base flood elevation, then this effect should be reflected in the amount by which our *Elevation* variable has increased over what it would have been without the device. Therefore, after having increased the value of *Elevation* (and thereby decrease the risk) the net effect of a device is its negative impact on the property's amenity value. However, the degree to which engineers incorporate this wave reduction when they define the property's BFE (i.e., the base flood elevation) is very uncertain.

The same story can be told for a device's interaction with *Geotime*. To the extent that the device has reduced erosion (and this is taken into account by the state Coastal Zone Management personnel when they define the current and projected erosion reference features), the net effect of a seawall is its impact as a disamenity. Because there is probably county-to-county variation on how erosion protective devices effect the definition of BFE and EHA (i.e., the erosion hazard area), the estimated coefficient for our *Armor* variable may not be as negative as we expect if it were a net amenity effect. On the other hand, property buyers might prefer the assurance of safety that a seawall lends to their property, and in this case the *Armor* variable would have a positive effect on sale price.

A similar situation is true for the variable *Sand Nourishment*, which is '1' if the owner reported that the nearest beach had been nourished prior to purchase and '0' otherwise. Nourishment should reduce risk, and this should be reflected in higher values for *Geotime* and *Elevation*, but we don't know whether CZM personnel consistently account for this when defining BFE and EHA. Nourished beaches can be compacted and they usually have shell fragments. Natural beaches with consistent sand quality should be more desirable. Therefore, the dummy variable *Sand Nourishment* should have a net negative effect as a disamenity.

Properties that are closer to the water will be worth more because of the better view, shorter walk to the beach, etc. The risk increasing aspects of being on the waterfront should be accounted for in *Geotime* and *Elevation*. Therefore, the net effect of being ocean front should be positive, and this effect is captured with the dummy variable *Waterfront*.

Given the array of questions we intend to address in the hedonic analysis, the list of variables in Table 1 seems reasonable. Following the lead of numerous other hedonic price studies, this model will be estimated with the log-log functional form. Also note that each variable's hypothesized positive or negative effect on price is marked with either (+) or (−). The hypotheses are described in the next subsection.

The vector of seven structural characteristics are fairly standard descriptor variables found in the literature. All of these variables should have a positive influence on the quality of the property and, therefore, its price. An exception to this is the *Age of House* which will be interpreted as the annual depreciation rate and therefore have a negative effect. The other exception is the *Age of Transaction*. Houses obviously costs more today than a few years ago, so this is expected to have a negative influence. Furthermore, this variable can yield an estimate of the average annual price index for coastal property.

Data for the Study

The sampling frame for this study consisted of 12 coastal counties from the Atlantic, Gulf, and Pacific regions that were selected by the Federal Emergency Management Agency. Within these counties, approximately 8,000 properties were selected randomly for inclusion in the study. For each property, a team of surveyors collected on-site data, another team collected descriptive data from county courthouses, while another team mailed survey questionnaires to the property owners.

The initial mailing was followed two or three weeks later by a postcard reminder, and a second mailing of the full questionnaire packet was made within one month. Of the 3,081 mail questionnaires returned, in the typical county two percent are nonresidential properties and twenty percent had been purchased as bare lots. These types of properties are not analyzed. Other properties cost less than $10,000 (indicating that they were probably gifts) while others cost more than $2,000,000. Deleting these outlier observations leaves about 55 percent of the properties, or 1,703. By comparing the known sampling frame characteristics with those of the returned questionnaires, we were able to calculate and apply correction factors for an over-representation of the properties closest to the shoreline.

The average property had been purchased in 1986 for an average of $215,000. Of course, recently-purchased coastal property costs much more than comparable lots did 14 years ago. The average property purchased within the last two years in our sample costs about $346,000. In 1996, the national median sale price of a new single-family house was $140,000.

Sixty-three percent of the houses were insured against flood losses. Fifty-five percent said they bought the insurance because their mortgage lender required it, implying that among property owners who had a choice the NFIP's market penetration is eight percent.

The average household size was 2.5 people and the average household income was about $100,000. The average head of the household was 58 years old and had attended college. 35 percent of the respondents are retired, while the remainder work full or part time. In summary, owners of coastal property are older, richer, better educated and they have more leisure time than the general U.S. population.

Two Types of Coastal Communities

To investigate the structural differences in the real estate markets we classified the properties in our data set into two groups. A property was judged to be in a community that had a good set of beach amenities if the community was favorably mentioned in *America's Best Beaches* (Leatherman, 1998). This book gives a state-by-state commentary on beaches that describes their attractive points. While this book is intended mainly as a vacation planning guide, Leatherman's reputation in coastal geology makes this book an authoritative source on conditions at specific beaches around the country. Note that a community did not have to earn one of Leatherman's "super beach" awards to be classified, but rather just mentioned favorably.

If the property's community was not mentioned in *America's Best Beaches*, then it was classified as being an ordinary coastal community. If it was not mentioned in the book it was probably because its beach had been degraded and it did not support an extensive tourist economy. This may be because its ecological diversity did not attract the type of tourists who enjoy looking at something more natural than hotels and cottages, or its recreation potential had declined, or both.

The communities that have been classified this way are listed in Table 2. Twenty-eight out of the 75 communities in the sampling frame are mentioned in *America's Best Beaches*. Within a state there are big differences. Virtually all of Dare County, NC, is classified as a Leatherman beach, while no community in Brunswick County, NC is listed. Communities in the Great Lakes region are not considered in Leatherman's book.

Empirical Results

A preliminary regression was run for each of two data sets: the Pacific coast (with three counties) and the Southeast US (with six counties from the Atlantic and three from the Gulf of Mexico). On each preliminary regression, a Chow test was conducted to determine whether the hedonic price schedules were structurally different between the two types of real estate markets, i.e. the Leatherman beach communities and the ordinary coastal communities. In both the Pacific and Southeast regions the null hypothesis of similarity was rejected at the 0.001 significance level. This means that property prices react differently to the *Distance to ERF* variable, for example, in the two types of real estate markets. Since the hedonic price schedules are structurally different, this means that the data set for each region should be split, and each of the four resulting data sets can be analyzed with separate regressions.

The averages of the variables for the four data sets are presented in Table 3. Note the substantial differences in property prices. In the Southeast, the average property in a Leatherman Beach community is valued 25.4 percent more than in an ordinary coastal community, and for the Pacific the decrease is 32.2 percent. These numbers are just raw averages, however. A better comparison is obtained from the two preliminary regressions described above because it allows the averages to be compared on a constant-quality basis. There, a dummy variable for whether or not the community is located in a Leatherman beach community indicated that the difference in the Southeast is 41.9 percent, while the difference in the Pacific is 19.5 percent.

From Table 3 it is also apparent that there substantial differences in the independent variables. The house sizes and parcels sizes tend to be larger in Leatherman beach communities. The average of *Geotime* is much higher in Southeast Leatherman beach communities, but this not the case for the Pacific. Most striking is differences in the variables that reflect better beach amenities for a property. In both regions the *Distance to ERF* variable is higher in Leatherman beaches. In the Southeast the average *Beach Width* is much greater in Leatherman beaches, but that is not the case in the Pacific. In the Southeast, *Sand Nourishment* and *Armor*ing are much less prevalent in Leatherman beaches.

The hedonic price regressions are presented in Table 4. Each of the models performs well with a large number of significant variables and a high r-square. Of the beach amenity indicators, *Distance to ERF* and *Beach Width* and are important predictors of higher property prices.

More important, though, is noticing the differences in the coefficients between the Leatherman beach and ordinary communities. In both regions the two amenity indicators have stronger impacts on property prices in Leatherman beach communities. For example, in the Southeast Leatherman beach communities the effect of proximity to the beach (as measured by *Distance to ERF*) is an order of magnitude larger than in the other communities. This means that in degraded-beach communities, the real estate market has lost much of its sensitivity to beach amenities like proximity and beach width.

These differences in how price responds to characteristics conforms with the outcome of the Chow test that was run. The test revealed that there are structural differences in the two types of real estate markets. Results from Tables 4 imply that the differences are manifested in the divergence of the regression coefficients. Looking across the coefficients of variables that indicate house quality, the *Size of House*, *Size of Parcel*, *Age of Transaction*, etc. are roughly similar in magnitude. However, the coefficients for *Distance to ERF* and *Beach Width* are much different. These are the consequences of beach degradation. Beach amenities matter less in determining land prices in ordinary beach communities because they attract fewer tourists than they do in Leatherman beach communities.

The amenity value of being *Waterfront*, however, is nearly the same between Leatherman beach and ordinary coastal communities. Our results suggest that buyers bid up waterfront property at an equal rate, regardless of the beach amenities that are available. Apparently, property buyers value the clear view of the water independently of the beach conditions. The buyers apparently place little extra value on the ecological diversity that borders on the property, or if they do, they may feel that its benefits are outweighed by the disadvantages of having beach goers stroll and frolic within shouting distance of their house.

The graphic difference between Leatherman beach and ordinary communities is illustrated in Figure 1 for the Southeast region. The price gradient is nearly flat in ordinary coastal communities, while in Leatherman beach communities it is higher and steeper. This serves to illustrate the potential loss to a community if its beach is degraded.

Consider a property in a Leatherman beach community and 100 feet from the ERF and is priced at $360,000. If the beach is degraded, the property value may decline to $310,000 for a loss of 13.9 percent. Price declines happen for all of the properties in the neighborhood, out to a distance of about 600 feet from the shore. More evidence about the effects of degradation are offered in the following section.

Overall, our findings agree with the hypothesis we stated earlier. The beach degradation causes coastal vacation communities to become more like ordinary residential communities, with amenity value concentrated among waterfront properties.

The Three Policy Alternatives

Table 5 describes the consequences of the three policy alternatives to coastal erosion. Hard stabilization is the policy most frequently applied to the erosion problem. In Georgia, for example, 55 percent of its developed coastline has been armored with rip-rap, seawalls and groin fields (Clayton, et al., 1992). The prevalence of armoring is understandable. It is the cheapest alternative for the individual property owner who has become distressed at his encroaching shoreline and pays someone to dump a load of rocks on his land. Over time, wave scouring at the base leads to constructing ever more substantial armoring of the shore until the property is protected by an impressive seawall.

This course of events has bad consequences for the beach. It is easy to observe that a natural beach in good recreational condition cannot coexist with armoring. In Georgia, for example, the beach disappears entirely at high tide along the armored sections. Sunbathing becomes a matter of finding a soft boulder to lay on. Volleyball is a water sport. Nesting habitat for birds and turtles is destroyed. Many experts go further and say that the armoring is directly responsible for beach degradation because the flow of sand is disrupted. Regardless of the reason, as the beach becomes degraded its recreational appeal declines and tourists go elsewhere, to another beach or to a mountain retreat or somewhere in between.

We calculate the impacts on property prices from beach degradation by using the hedonic price regressions as we did in the previous sections. For the Southeast region, the results from Table 4 suggest that in a Leatherman beach community the waterfront properties would gain 6.5 percent in value from armoring (although this effect is statistically insignificant). Waterfront properties in the ordinary beach communities, on the other hand, would gain more than twice as much, 13.9 percent, and this effect is statistically significant. However, this effect would be limited to only the waterfront properties because inland properties would gain no additional erosion protection. In the Pacific, waterfront properties actually lose 36.9 percent of value following armoring in the Leatherman beach communities, and this reduction is statistically significant. In the ordinary communities, Pacific properties gain six percent of value but the effect is not significant.

Thus, these results demonstrate that there are private-party benefits to armoring. However, because of the reasons stated earlier, we believe that armoring is the first step in an unstoppable process that leads to degradation of the beach's recreational amenities and ecosystem, the loss of tourists and the eventual loss of property values.

In terms of Figure 1, property values in the average Southeast Leatherman beach community would shift downward to those of the ordinary community. Mathematically, this loss of value can be found by integrating the hedonic price functions over the range 1 to 600 feet. A good approximation of the price changes can be found by applying the trapezoid rule. Assuming that the property lots are roughly uniform, the integration can be performed in 100 foot intervals, with the waterfront's loss being offset by the 6.5 percent gain from armoring.

For the six properties in this cross section of the average Leatherman beach community in the Southeast US, beach degradation reduced the total of their property value from $1,955,200 to $1,808,600, for a percent decrease of 7.5 percent. Of course, as Figure 1 suggests this loss primarily impacts the properties closest to the water. According to the spreadsheets, the waterfront property's value goes from $502,500 to $408,500 for an 18.7 percent loss.

This comparison is more dramatic in the Pacific region (Figure 2). The 63 properties in the Leatherman beach communities have an initial total value of $13,882,000, but it decreases to $4,331,800 in the ordinary coastal communities. This represents a 68.8 percent decline. For the waterfront property, value decreases from $5,730,000 to $1,209,500 for a 78.9 percent decline.

Thus, in both the Pacific and the Atlantic regions, a Leatherman beach community will suffer significant property value losses in the long-term as beach conditions are degraded. These declines are also illustrative of the losses to be expected by the average ordinary beach community, if its amenities were to become further degraded so it resembles the worst of the lot. Conversely, they also illustrate what may be gained if a community manages its coastal resources, reverses the trend of degradation and attracts more visitors to its shore.

How long would it take for these property value declines to materialize? Small towns in rural America have experienced this process in their downtown areas. Starting at some baseline in the 1970's or 80's when the downtown had a diverse retail sector, many have declined to where they resemble ghost towns with a few store fronts occupied by pawn and consignment shops. The retail activity has moved to the Walmart at the edge of town or (encouraged by low gas prices and better roads) it moved to larger neighboring towns.

The process for coastal communities would be a similar, slow downward spiral of land use types as tourists visit the community less often. The once-prestigious motels reduce their room rates, then they cut back on grounds maintenance, and they may finally go out of business. The rental cottages that once earned $3,000 per week no longer attract affluent clientele and they may revert to ordinary residential use. If the community's beach becomes degraded while its competing, neighboring beach communities remain in a good condition, then these changes can happen fairly quickly.

This process of beach degradation and property value reduction can be avoided by the other two erosion management strategies from Table 5. Beach nourishment is practiced in some of the Atlantic Leatherman beach communities, and this increases property value by 15.5 percent, when this value increase is applied to the difference in property values, $146,700, the difference becomes $170,000 for the cross section of six properties. This represents the gains to property values from maintaining it as a Leatherman beach community by sand nourishment. This figure can be compared with the present value of projected nourishment costs for a type of benefit-cost analysis.

Evaluating the feasibility of the other strategy from Table 5, letting nature take its course, involves no armoring and the sacrifice of the waterfront property to the water. However, when this is done, the property that was formerly second-row becomes waterfront and gains all of the amenity value lost by the sacrificed property. The second and third row, etc., experience similar effects so to the community all that has been sacrificed is the value of the property with the least amount of amenity value.

To motivate this analysis, assume that initially these six houses are on a narrow island with no room inland for house relocation. Also, suppose the soon-to-be sacrifice property's owner is willing to sell his endangered investment for its appraised value, as determined from the hedonic function. After he armors his shoreline and the beach becomes degraded, this appraised value would be $408,500. If this scheme is to be self-financed with no outside subsidies, then the remaining five property owners to have to come up with $408,500 to compensate the owner of the sacrificial property.

Their problem is to judge whether they could afford this out of (a) their asset appreciation that results from moving closer to the front row and (b) the asset devaluation they would avoid by preventing the community's beach from degrading to ordinary status from Leatherman beach status. According to the spreadsheet analysis, the sum of these five property values for the average Atlantic Leatherman beach community is $275,000, or $133,000 less than what the property owner would demand for fair compensation. On the other hand, in the Pacific region property values are so much different between Leatherman beach and ordinary communities that this compensation scheme would be very feasible.

Conclusions

In this paper we have attempted to present evidence on how all property owners in a community are affected when beach conditions deteriorate. Of course, the waterfront property owners experience adverse affects. However, if the community is viewed a the sum of interdependent properties, then it is possible to quantify the negative externalities that arise from the hard stabilization erosion management technique.

First, we divide the data set into two classes of properties: those located in a Leatherman beach community and those that are in ordinary coastal communities. We run two separate hedonic regressions and find that in the Southeast US, the average property in a Leatherman beach community is valued 41.9 percent higher than a comparable property in an ordinary coastal community. In the Pacific, the difference is 19.5 percent. Therefore, all property owners stand to suffer large losses in asset values if beach conditions are degraded.

In the Southeast US, a waterfront property can increase its value by 6.5 percent with coastal armoring, but inland properties gain nothing. If beach conditions deteriorate after the armoring so that recreation is significantly reduced, each inland property will lose a percent of its value that decreases with more distance from the shore.

In the average Pacific coastal community that has a recreational beach, the inland property owners can afford to preserve their property values by paying the waterfront properties to forego hard stabilization. In the Southeast US, this solution to the problem of erosion management is less certain. Overall, there is strong evidence that coastal property should act in their own financial self-interest to preserve the recreational potential and ecosystem diversity of their environment.

References

Clayton, Tonya D., et al. *Living with the Georgia Shore.* Durham: Duke University Press. 1992.

Davison, A. Todd (1993). “The National Flood Insurance Program and Coastal Hazards.” In: *Proceedings, Coastal Zone ‘93*. 1377-1391.

Dean, Cornelia. 1999. *Against the Tide: The Battle for America’s Beaches*. New York: Columbia University Press.

Freeman, A. Myrick (1993). *The Measurement of Environmental and Resource Values*. Washington: Resources For the Future.

Kemper, S. 1992. This beach boy sings a song developers don't want to hear. *Smithsonian* 23(7):72-85.

Kriesel, Warren, Alan Randall and Frank Lichtkoppler (1993). "Estimating the Benefits of Shore Erosion Protection in Ohio's Lake Erie Housing Market". *Water Resources Research*. 29(April): 795-801.

Leatherman, Stephen P. 1993. Modes of shoreline behavior: Erosion rate analysis using geomorphic principles. In Proceedings of International Coastal Symposium, Hilton Head Island, SC, pp. 218-223.

Leatherman, Stephen P. *America's Best Beaches*. Miami: Florida International University Press. 1998.

MacDonald, Don N., James C. Murdoch and Harry L. White (1987) "Uncertain Hazards, Insurance, and Consumer Choice: Evidence from Housing Markets." *Land Economics,* 63(November): 361-71.

O'Brien, M. P. 1982. Memorandum covering a document entitled "Saving the American beach: a position paper by concerned coastal geologists". *Shore and Beach*. 50(2):6-8.

Pilkey, O.H., J.D. Howard, B. Brenninkmeyer, R.W. Frey, A.C. Hine, J.C. Kraft, R. Morton, D. Nummedal, and H. Wanless. 1982. Saving the American beach: a position paper by concerned coastal geologists. *Shore and Beach*. 50(2):3-4.

Smith, V. Kerry (1985). "Supply Uncertainty, Option Price and Indirect Benefit Estimation." *Land Economics*, 61(3): 303-307.

Table 1: Definition of Variables used in hedonic model of coastal property values.

House Size	natural log of square footage of house's living area (+)
Parcel Size	log of square footage of the property parcel (+)
Bedrooms	log of number of bedrooms (+)
Geotime	geological time, i.e. the log of the number of years until the distance between the property and the erosion reference feature is reduced to zero. (+)
Geotime Squared	the square of *Geotime*, added to lend more flexibility to the functional form (-)
Elevation	reference elevation of first floor above base flood elevation, measured in the logged number of feet (+)
Distance to ERF	log of feet from the erosion reference feature to the structure (−)
Beach Width	log of high tide beach width, in feet, if the nearest shore has no hard stabilization, set to zero otherwise (+)
Distance to CBD	log of miles from the property to the closest central business district (-)
Age of Transaction	number of years since property purchase (−)
Age of House	number of years since the house was constructed (−)
Fireplace	1 if fireplace, = 0 otherwise (+)
Brick or Stone	1 if brick or stone exterior finish, = 0 otherwise (+)
CBRA	1 if located in CBRA area and the house was built after 1983, = 0 otherwise. A measure of flood insurance availability. (−)
Sand Nourishment	1 if nearest beach has been nourished, = 0 otherwise (−)
Armor	1 if property is waterfront and its shore has hard stabilization, = 0 otherwise (+)
Built Post-FIRM	1 if house built after date of 'regular' NFIP status, = 0 otherwise (+)
Sold Post-FIRM	1 if house sold after date of 'regular' NFIP status, = 0 otherwise (−)
Cliff	1 if house is perched on a cliff, =0 otherwise (+)
Waterfront	1 if parcel is waterfront, = 0 otherwise (+)

Table 2. Classification of coastal communities into whether they were mentioned favorably in *America's Best Beaches*. 75 coastal communities from twelve states, 1999.

"Leatherman beach" Communities	Ordinary Coastal Communities	
Coronado, CA	Carlsbad, CA	Beverly Beach, OR
La Jolla, CA	Del Mar, CA	Gleneden Beach, OR
Santa Cruz, CA	Encinitas, CA	Lincoln Beach, OR
Bethany Beach, DE	Imperial Beach, CA	Lincoln City, OR
Dewey Beach, DE	Ocean Beach, CA	Newport, OR
Fenwick Island, DE	Oceanside, CA	Otter Rock, OR
Rehoboth Beach, DE	San Diego, CA	Roads End, OR
Cape Canaveral, FL	Solana Beach, CA	South Beach, OR
Cocoa Beach, FL	Aptos, CA	Debidue, SC
Captiva, FL	Capitola, CA	Garden City Beach, SC
Sanibel, FL	La Selva Beach, CA	Pawleys Island, SC
Jekyll Island, GA	Live Oak, CA	Follets Island, TX
Sea Island, GA	Rio Del Mar, CA	Quintana, TX
Avon, NC	Watsonville, CA	San Luis Island, TX
Buxton, NC	South Bethany Beach, DE	Surfside Beach, TX
Duck, NC	Floridana Beach, FL	Caplen, TX
Frisco, NC	Indialantic, FL	Crystal Beach, TX
Hatteras, NC	Melbourne Beach, FL	Gilchrist, TX
Kill Devil Hills, NC	Satellite Beach, FL	Jamaica Beach, TX
Kitty Hawk, NC	Boca Grande, FL	
Nags Head, NC	Bonita Shores, FL	
Rodanthe, NC	Fort Myers Beach, FL	
Salvo, NC	St. Simons Island, GA	
Sanderling, NC	Caswell Beach, NC	
Southern Shores, NC	Holden Beach, NC	
Waves, NC	Long Beach, NC	
Litchfield Beach, SC	Oak Island, NC	
Galveston, TX	Whalebone, NC	

Table 3: Averages of Variables, 2 regional groups of coastal counties, with observations sorted into whether or not they are inside a community mentioned in *America's Best Beaches*, 1998-99.

	Averages			
	South East Region		Pacific Region	
Variable	Leatherman beach	Ordinary beach	Leatherman beach	Ordinary Beach
Property price (1986 $)	$198,100	$157,900	$382,300	$289,186
Size of House (sq. ft.)	1898.870	1818.710	2373.497	1971.5
Size of Parcel (sq.ft.)	13943.101	11784.28	8718.906	6265.301
Bedrooms (number)	3.526	3.390	3.152	2.881
Geotime (years)	9205.312	6475.921	3637.623	4706.101
Geotime Squared (years)	84732025	41925625	76048779	72863688
Elevation (feet)	18.944	16.290	n.a.	n.a.
Distance to ERF (feet)	432.589	305.301	367.727	182.499
Beach Width (feet)	79.539	53.995	40.866	100.731
Distance to CBD (miles)	16.528	17.785	5.482	12.568
Age of Transaction (years)	11.158	12.605	15.238	14.891
Age of House (years)	24.184	28.980	50.428	38.553
Fireplace (0-1)	0.522	0.333	0.809	0.781
Stone or Brick (0-1)	0.099	0.069	0.104	0.075
CBRA (0-1)	0.037	0.007	n.a.	n.a.
Sand Nourishment (0-1)	0.294	0.445	0.076	0.071
Armor (0-1)	0.042	0.106	0.219	0.171
Built Post-FIRM (0-1)	0.626	0.418	n.a.	n.a.
Sold Post-FIRM (0-1)	0.869	0.725	n.a.	n.a.
Cliff (0-1)	n.a.	n.a	0.991	0.837
Waterfront (0-1)	0.441	0.476	0.371	0.406
Number observations	631	637	63	248

Table 4: Summary of Regression Results for the Hedonic Model, 2 regional groups of coastal counties, with observations sorted into whether or not they are inside a community mentioned in *America's Best Beaches*, 1998-99. (Dependent variable: log of property purchase price).

	Beta Coefficients and Significance Levels			
	South East Region		Pacific Region	
Variable	Leatherman beach	Ordinary Beach	Leatherman beach	Ordinary Beach
Intercept	4.351***	6.968***	6.108**	10.155***
Size of House	0.542***	0.392***	0.115	0.326***
Size of Parcel	0.162***	0.177***	0.372**	0.169**
Bedrooms	0.232**	0.135**	0.214	0.042
Geotime	0.172**	0.082*	1.544***	-0.162
Geotime Squared	-0.011**	-0.006*	-0.114***	0.007
Elevation	0.426***	0.162**	n.a.	n.a.
Distance to ERF	-0.076**	-0.009	-0.235**	-0.045**
Beach Width	0.028**	0.014	0.060*	-0.003
Distance to CBD	-0.038*	-0.033	-0.461**	0.018
Age of Transaction	-0.048***	-0.059***	-0.103***	-0.079***
Age of House	-0.003*	-0.004**	0.002	-0.006**
Fireplaces	0.145**	0.309***	0.539**	0.064
Stone or Brick	0.044	0.023	0.449*	-0.122
CBRA	-0.013	0.453**	n.a.	n.a.
Sand Nourishment	0.155**	-0.034	-0.008	0.058
Armor	0.065	0.139*	-0.369*	0.060
Built Post-FIRM	0.118*	0.061	n.a.	n.a.
Sold Post-FIRM	0.386***	-0.063	n.a.	n.a.
Cliff	n.a.	n.a.	0.061	0.109
Waterfront	0.258***	0.210***	0.271*	0.433***
R-square	0.765	0.752	0.942	0.819
Number observations	631	637	63	248

All continuous variables are in log terms, except *Age of Transaction* and *Age of House,* which have not been transformed. * indicates that the variable is significant at the 0.2 level or lower, ** is significant at the 0.05 level, and *** means it is significant at the 0.001 level.

Table 5: Policy alternatives to erosion threats, and their side effects.

Policy Alterative	Harmful Effects	Beneficial Effects
Let nature take its course.	Buildings destroyed, waterfront property owners lose total investment.	Neighboring inland property becomes waterfront, its value is increased 25.8 percent. Natural beach conditions are preserved. Tourism levels are maintained.
Beach nourishment.	New sand may be less desirable than original sand, may contain harmful substances. Dredging disrupts ecosystem at borrow site. Nourishment costs may be frequent. If financed by general tax revenues, nonusers are forced to pay for it.	Tourism levels maintained. All property values increase 0.03 percent for every one percent addition to beach width Waterfront properties gain some storm protection.
Hard stabilization of shoreline.	If beach is degraded, tourism is reduced and all properties lose 3 percent of value. Waterfront properties lose their buffer zone, their storm-driven debris may damage neighboring houses and cause higher disaster assistance payments. If flow of sand is interrupted then neighboring beaches are degraded. Loss of nesting habitat for birds, turtles, etc. Erosion control structures may impede navigation. If financed by general tax revenues, nonusers are forced to pay for it.	Buildings saved from destruction. Each waterfront property has impressive protection and gains six percent value.

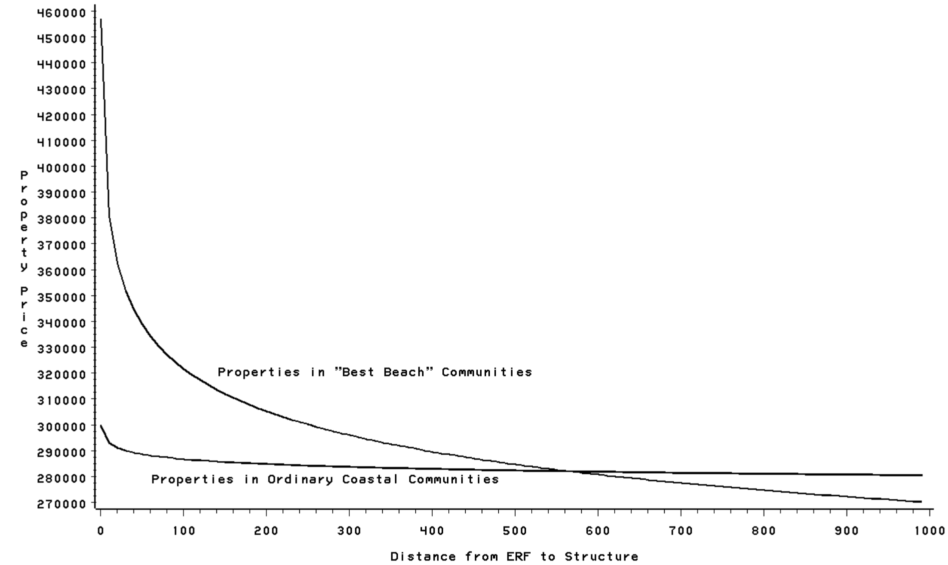

Figure 1. How property price responds to distance from the erosion reference feature, holding *Geotime* constant, in communities listed in *America's Best Beaches* versus those that are not. Nine southeastern U.S. coastal counties, 1998-99.

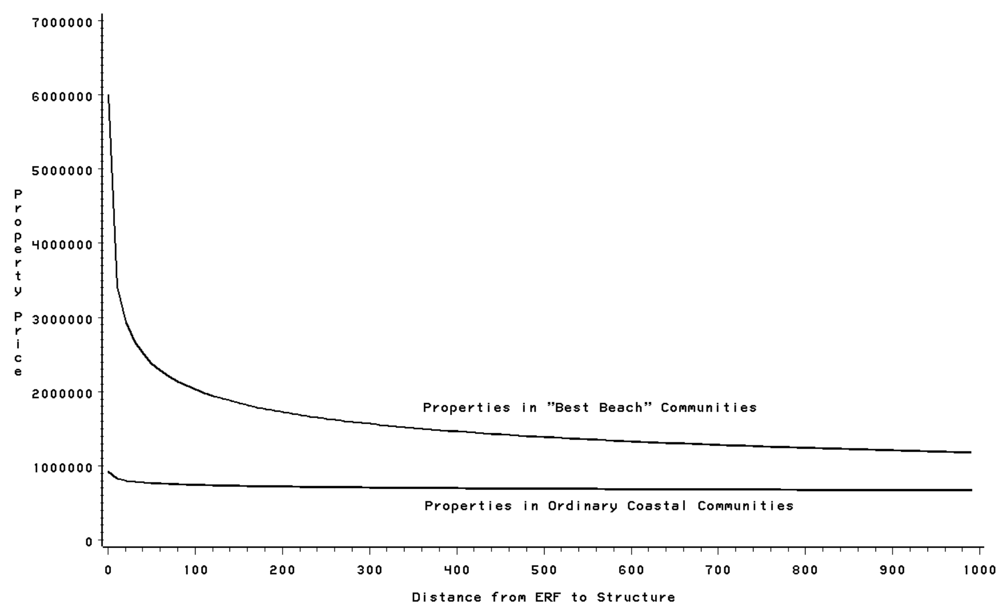

Figure 2. How property price responds to distance from the erosion reference feature, holding *Geotime* constant, in communities listed in *America's Best Beaches* versus those that are not. Three Pacific coastal counties, 1998-99.