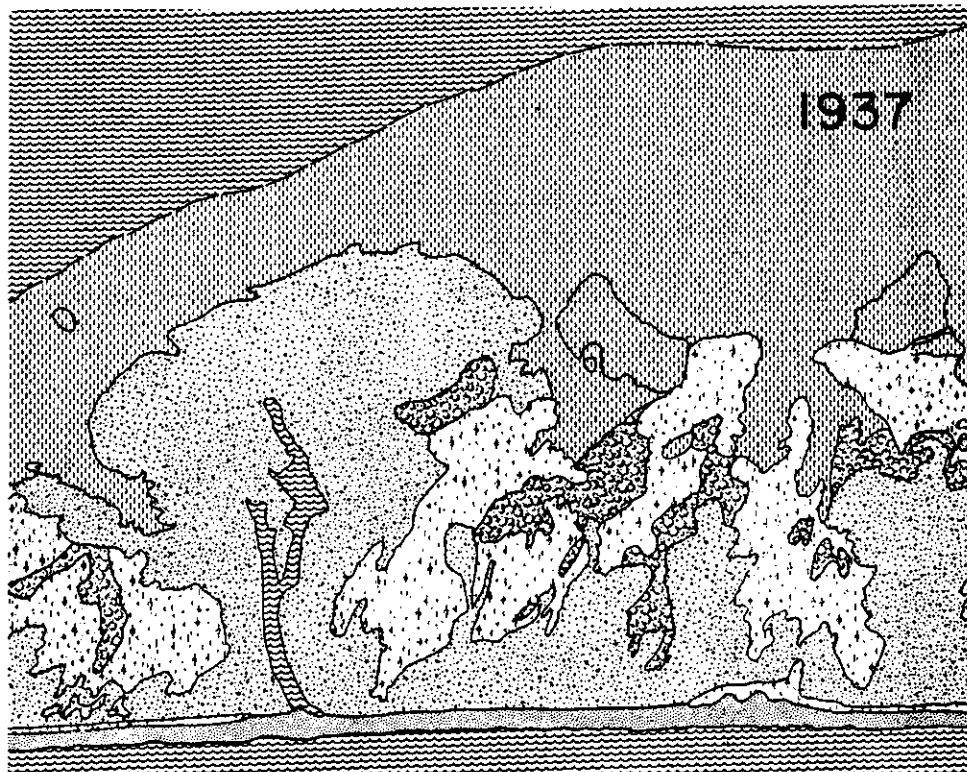
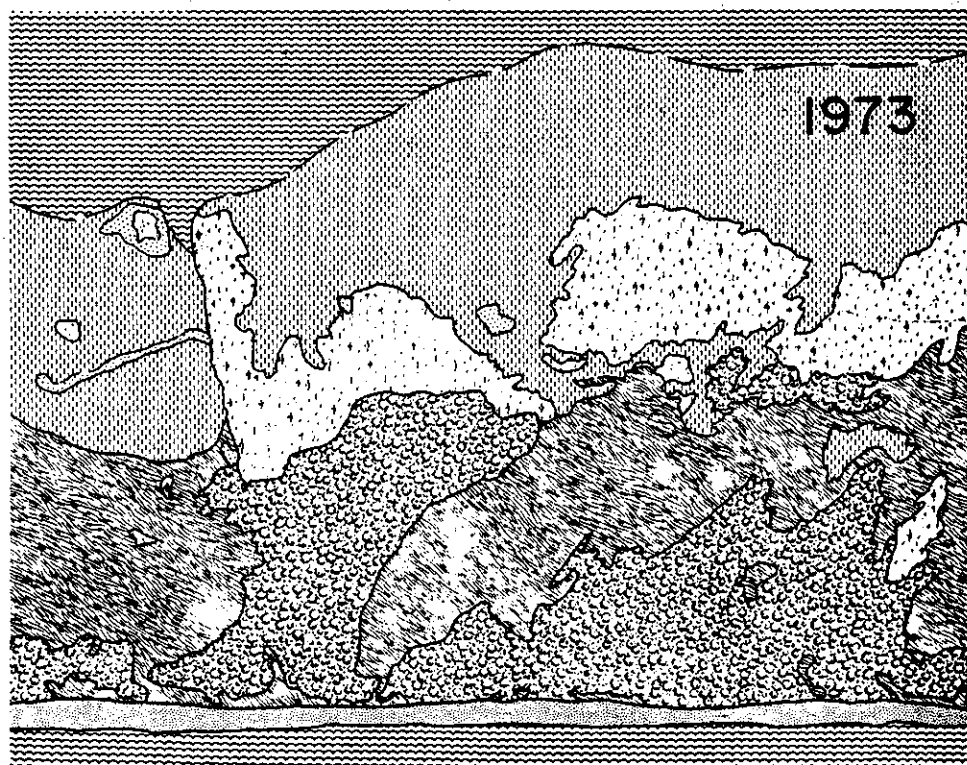




A GEO-ECONOMIC EVALUATION OF BARRIER
ISLAND DEVELOPMENTS



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MAY 1975

A GEO-ECONOMIC EVALUATION OF BARRIER
ISLAND DEVELOPMENTS

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ABSTRACT

A Geo-Economic Evaluation of Barrier Island

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Geo-economic analysis provides an efficient method of property evaluation in coastal environments. It establishes development procedures which are sensitive to risks, uncertainties, and externalities associated with coastal construction. The objective is to identify the potential hazards of building in peculiar environments due to natural geologic processes active in the coastal zone, and to utilize this information in directing the allocation of coastal properties.

Performing a geo-economic evaluation requires a keen understanding of geology, economics, and management. The analysis consists of four parts: (1) preliminary site investigation, (2) laboratory analysis, (3) data reduction, and (4) conclusions. The preliminary site investigation should be conducted by a geologist or engineering geologist, and can be completed in a few days. The laboratory analysis consists of environmental geologic mapping from historical maps and aerial photographs. Data from these maps must be interpreted and then reduced (using matrices) to a form that can be used in an economic analysis.

The results indicate that hazards to development on barrier islands are highest in washover, beach, and migrating dune areas. The vegetated flatlands are most suitable for development; however, barrier island environments are dynamic, and therefore development procedures must be responsive to environmental changes. Setback lines are required in the beach and foredune areas; construction must be restricted to the back island flats. Precautionary measures may be necessary where banner complexes, washover areas, or other potentially hazardous areas exist.

Geo-economics is a valuable tool that can be used by public, private, and corporate interests to aid in making decisions about the use and allocation of coastal properties. At this time, competition for the use of our scarce coastal resources is a perplexing and difficult problem in coastal zone management. Geo-economics is a new approach to problem solving that utilizes pertinent, factual information to evaluate coastal developments.

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INTRODUCTION

Texas is fortunate to have one of the few largely undeveloped coastlines remaining in the United States. This is primarily because development in Texas originated in the interior rather than on the coast [5]. However, recent studies indicate that the Texas coastal zone will experience a surge of recreational, residential, and industrial development in the very near future [32]. In response to this anticipated growth, the Texas Coastal Zone Management Proposal, March 1974, states that

the goal for Texas in the coastal zone is to achieve a balance between the conservation of coastal resources and the satisfaction of the needs of the people of Texas for use of the coastal environment The process for achieving this balance must also take into account the costs that may accrue to the public or other entities as a result of unwise individual decision-making that is not reflected in the private market [35].

Hidden costs associated with the private market will be examined in this study.

Currently, Fall 1974, the market price of barrier island real estate, as determined by supply and demand, does not reflect economic risks, uncertainties, and externalities created by geologic processes.¹

All citations in the following pages follow the style of The American Economic Review.

¹ For example, beachfront property on South Padre Island has sold for the same price without regard to the fact that well-established vegetated foredunes were present on the property or that the property occupied the site of a recent washover (personal interview with Gene Stanley, November 1, 1974, South Padre Island Development Company, Inc.).

Barrier island property is scarce, and the public's expressed desire for ownership or use of this unique area (value) is extremely high.² Hence, the market price reflecting this value is extremely high.³

Market price is often the only criteria used in determining value. The selling price of land on Texas' barrier islands is often the same per acre of land within a particular tract no matter what environments exist on or processes act on the land within distinct property limits. Moreover, these environments and processes are likely to change with time. The potential buyer of any property should be informed of the risks, uncertainties, and externalities which are associated with his investment. The Interstate Land Sales Full Disclosure Act (ILSA) was created specifically for this purpose [23].⁴ That act requires the seller of land to prepare a Property

² The use of the beach area is valued highly by both the private landowner who owns the land down to high tide and the general public which has used this same land for recreating. This is evidenced by the disputes over the right to have access to the beach as provided by the Open Beaches Act of Texas, Article 5415d Vernons Annotated Texas Statutes. One case, concerning Article 5415d, currently pending is John L. Hill, Attorney General of Texas, et al. v. West Beach Encroachment, et al., Case No. 108,156 filed in the District Court of Galveston County, 122nd Judicial District [8].

³ Some beachfront property on South Padre Island selling in six acre lots is currently marketed at \$70,000 per acre (personal interview with Lawrence Young, November, 6, 1974, Tompkins-Young Real Estate, South Padre Island, Texas).

⁴ "The primary purpose of the Interstate Land Sales Full Disclosure Act is to require the seller of subdivided property to make full, complete, and accurate disclosure of all relevant information about the property The intent is to 'enable the buyer to know as much as the seller about the property being offered'" (from W. H. McMullen, Jr. [28]).

Statement which must include various types of information needed by the buyer to make a rational and informed decision regarding his prospective purchase. However, there are thirteen exemptions which relieve the seller of the obligation of preparing a Property Statement.⁵ As a result, some developers design their subdivision programs specifically to exempt them from full disclosure. Clearly, it is the buyer's decision whether or not to buy and whether or not his investment is sound.

The proposed geo-economic analysis can be an aid in determining economic risks, uncertainties, and externalities and can be used by (1) the buyer in decision-making where there is no Property Statement to assist him, (2) the developer in determining a fair and reasonable mode of development with due respect to environmental hazards and benefits, (3) the seller in compliance with ILSA, and (4) the land planner and local governments in determining optimum land usage, zoning regulations, and tax evaluation. The objective here is to describe an analytical tool that can be used in valuation of land. For purposes of illustration and description, aspects of barrier island property development will be dealt with as an example of this process.

⁵ For a more detailed description of the Act and the exemptions, refer to W. H. McMullen [27].

CRITERIA

Preparation of the geo-economic analysis developed in this thesis required literature research in geology, economics, and management. Relevant criteria were established within each field through an investigation of previous related works and will be referenced in the pages to follow.

Geology

Geology is the study of earth processes. Portions of Earth history may be deciphered from the record which geologic processes imbedded in the rocks of the Earth. Through paleo-environmental reconstruction, geologists can determine what the earth was like in the past and how it came to be as it is today. Geologic processes and environments are two closely integrated criteria which must be understood before the geologic history of an area can be determined. The geologic history of barrier islands is one of dynamic equilibrium.⁶

Barrier islands on the Texas coast today are recent features, geologically speaking. Geologists agree that these barrier islands were created some 5,000 years ago as sea level began to stabilize following the last great recession of the ice caps. However, the

⁶ Dynamic equilibrium is a type of equilibrium that is characterized by continual change (as opposed to static equilibrium).

original process which created these islands is actively debated.⁷ The theories proposed by G. K. Gilbert [12], J. H. Hoyt [19], and E. G. Otvos [31] are worth recognition.

Gilbert believed that barrier islands were formed through spit accretion, as illustrated in Figure 1-A (p. 6). Sand is deposited by longshore currents propagating spit growth at offsets along the coastline, Figure 1-A(1). Continuous deposition forms a peninsula, Figure 1-A(2), which is enlarged through spit accretion until eventually the peninsula is breached by storm waves, Figure 1-A(3), severing a portion of the peninsula from the mainland leaving an island.

Hoyt proposed that barrier islands were formed as a result of submergence, Figure 1-B. This theory propounds that the low-lying area behind the mainland beach and dune ridge was flooded by a rise in sea level forming a lagoon behind the beach and dune ridge creating the islands.

Otvos describes barrier island formation as a function of breaking waves, as illustrated in Figure 1-C. Sand is deposited in the form of an offshore bar at the point where waves break. Otvos claims that this process can eventually build a bar above sea level that once stabilized by vegetative cover will remain as an offshore island such as the barrier islands on the Texas coast. In truth, the

⁷ A more detailed discussion of this geologic debate can be found in C. W. Cook [4], J. J. Hoyt [19], J. J. Fisher [10], and J. H. Hoyt [20].

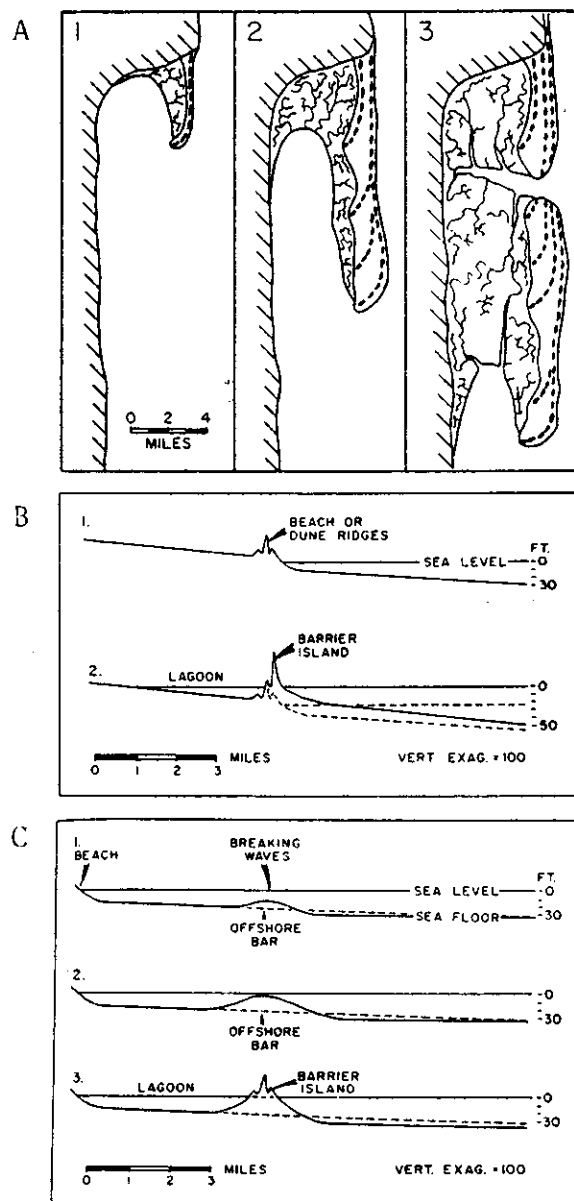
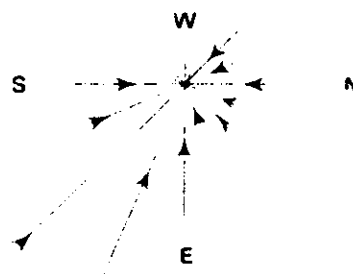


Figure 1. Three theories on barrier island formation.

formation of barrier islands is probably some combination of these three theories working together.

All active geologic processes on the barrier islands of Texas are wind or water related, or both. Since its time of formation, Padre Island has widened extensively [10], the beach has grown gulfward as a result of sand delivered to it by longshore currents and breaking waves, and the back side of the island has been extended some distance into Laguna Madre by hurricane washover deposits and windblown sand. The prevailing winds⁸ on Padre Island are from the southeast, as illustrated in Figure 2. The orientation of chutes

Figure 2. Percentage frequency of surface wind direction, 1951-1960, Kingsville Naval Air Station. (From the Bureau of Economic Geology [3]).



through the foredunes is parallel to the prevailing wind direction.⁹

⁸ Prevailing winds are those winds that blow most continuously or for the greatest amount of time from the same direction.

⁹ Chutes are breaches in the foredune ridge created by storm wave activity or wind or man-induced erosion [25]. They provide a path through which sand blown up the beach by the prevailing southeasterly winds is directed to the back island dune fields. It is through these chutes that the greatest amount of wind-transported sediment eventually reaching the Laguna Madre flats must initially pass.

When the wind is from the north or west, the shallow waters of Laguna Madre are blown across the back island mud flats flooding most of the low-lying areas of the island.¹⁰ The predominant winds,¹¹ those which account for the greatest amount of sediment transport, are variable, mainly from the east, south and north. The resultant wind-blown sand transport on Padre Island near Malaquite Beach is almost due west, as illustrated in Figure 3.

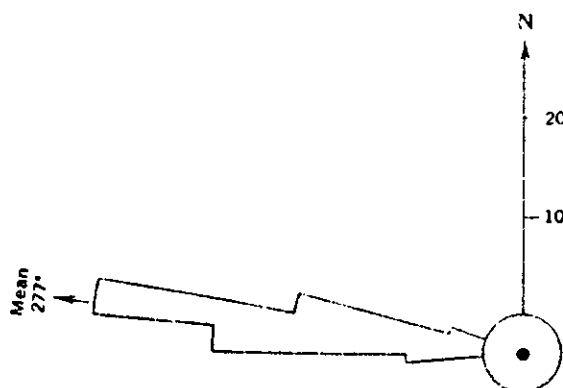


Figure 3. Trends of longitudinal dunes in the back-island active dune field. The trends of these dunes give the best estimate of the average direction of sand movement by winds throughout the year, in situations where the influences of vegetation and water are at a minimum. 25 measurements from aerial photographs. Radial scale in percent. (From R. E. Hunter and K. A. Dickenson [22]).

¹⁰ These low-lying areas subject to inundation by wind-blown waters are called wind tidal flats.

¹¹ Predominant winds are those winds that deliver the greatest force but do not necessarily blow for the longest time.

As wind-driven sand fills in Laguna Madre, wind-driven waves assault the beach. Whenever waves approach the beach at an angle, currents are produced parallel to the beach and in the direction of wave approach, called longshore or offshore currents. These currents carry tremendous amounts of sediment which must eventually be deposited on the beach or be carried offshore where longshore currents meet. Figure 4 illustrates the direction of longshore currents on

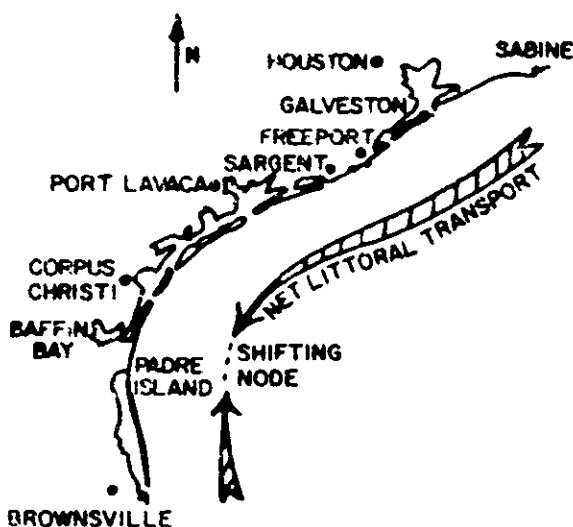


Figure 4. Longshore currents on the Texas coast (after Carrothers and Innis 1960, in W. N. Seelig and R. M. Sorenson [33]).

the Texas Gulf coast.¹² Occasionally storm waves erode the beach and sometimes wash over it carrying sediment across the island into

¹² The direction of offshore currents will vary with meteorological conditions, but will most often comply with that direction produced by the prevailing winds as shown in Figure 4. It is interesting to note that the longshore currents converge in the vicinity of Yarbrough Pass and that this is probably the reason why an abundance of large shells and refuse occupy the beach in this area.

Laguna Madre. As a result, the island is migrating landward. An aerial photograph taken on Padre Island at old Murdock Pass (now Yarborough Pass) in 1937 is illustrative of a hurricane washover, Figure 5 (p. 11). A washover channel can be recognized in the center of the photograph. This area is one of extremely rapid currents during storm periods which cause significant destruction to structures occupying the area.

At least ten different geologic environments can be recognized on Padre Island. These are: (1) Gulf of Mexico, (2) beach, (3) foredunes, (4) vegetated flats, (5) banner complexes or migrating dune fields, (6) sand flats, (7) mud flats, (8) washover fans, (9) Laguna Madre, and (10) dredged channels and spoil banks. The configuration of these environments varies at different points along the island, as illustrated in Figure 6 (p. 13) and will in fact vary at each location from time to time as the island is subjected to drought, hurricane surge, or other extreme conditions, Figure 7 (p. 15).¹³

Barrier islands exist in dynamic equilibrium. Therefore, any property evaluation within this unique area must take into consideration the natural phenomena described above in order to more truly estimate the value of the environmental goods unique to these properties. Geo-economic analysis attempts to incorporate these geologic phenomena into an economic analysis.

¹³ For a more detailed discussion of environmental complexes of the south Texas coast and the effects of hurricanes refer to M. O. Hayes and A. J. Scott [15] and M. O. Hayes [14].



0 1000 2000 FEET

A horizontal scale bar with three segments. The first segment is labeled '0', the second '1000', and the third '2000 FEET'.

Figure 5. A typical hurricane washover fan. Aerial photograph by Tobin Aerial Surveys, San Antonio, Texas.

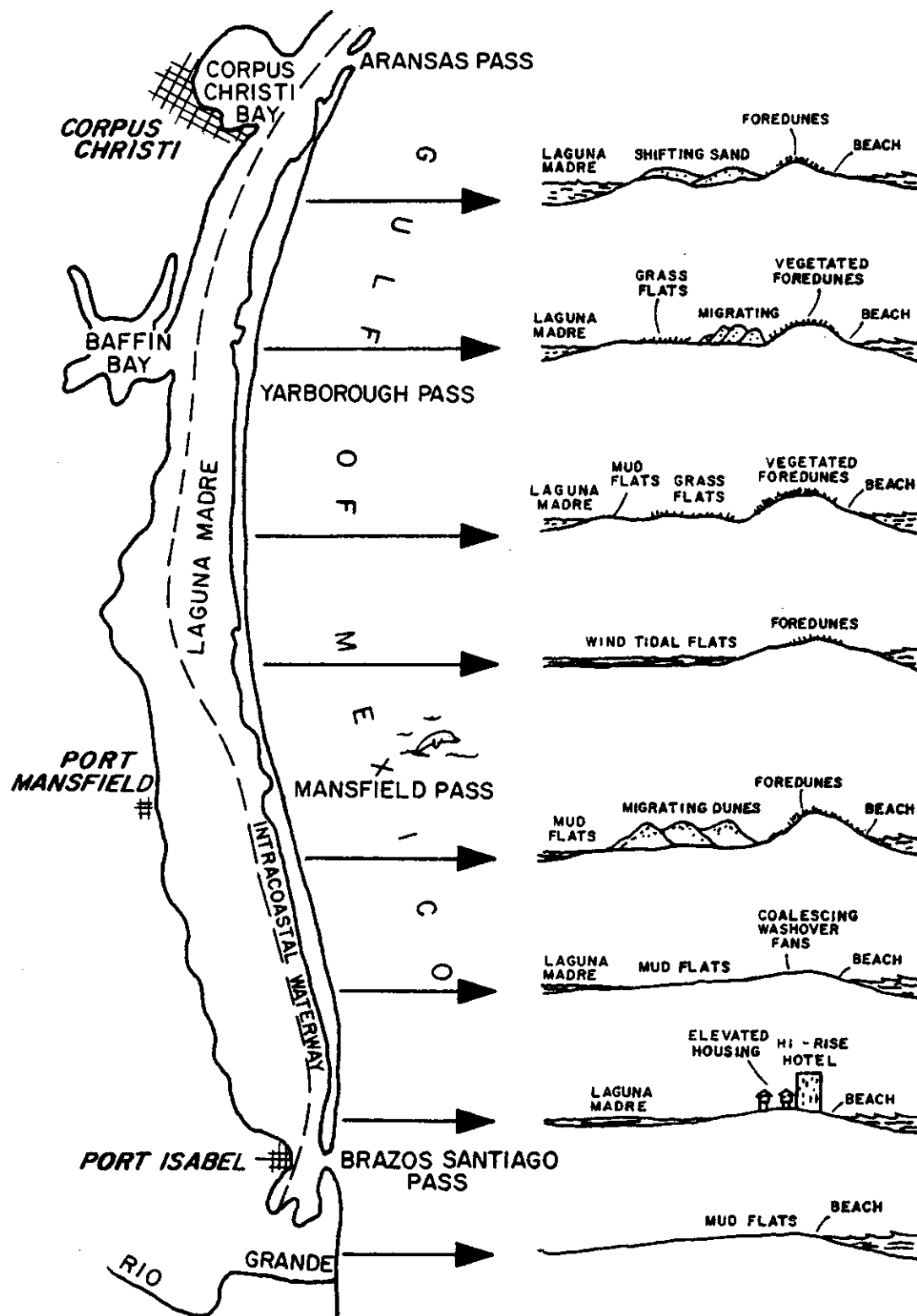


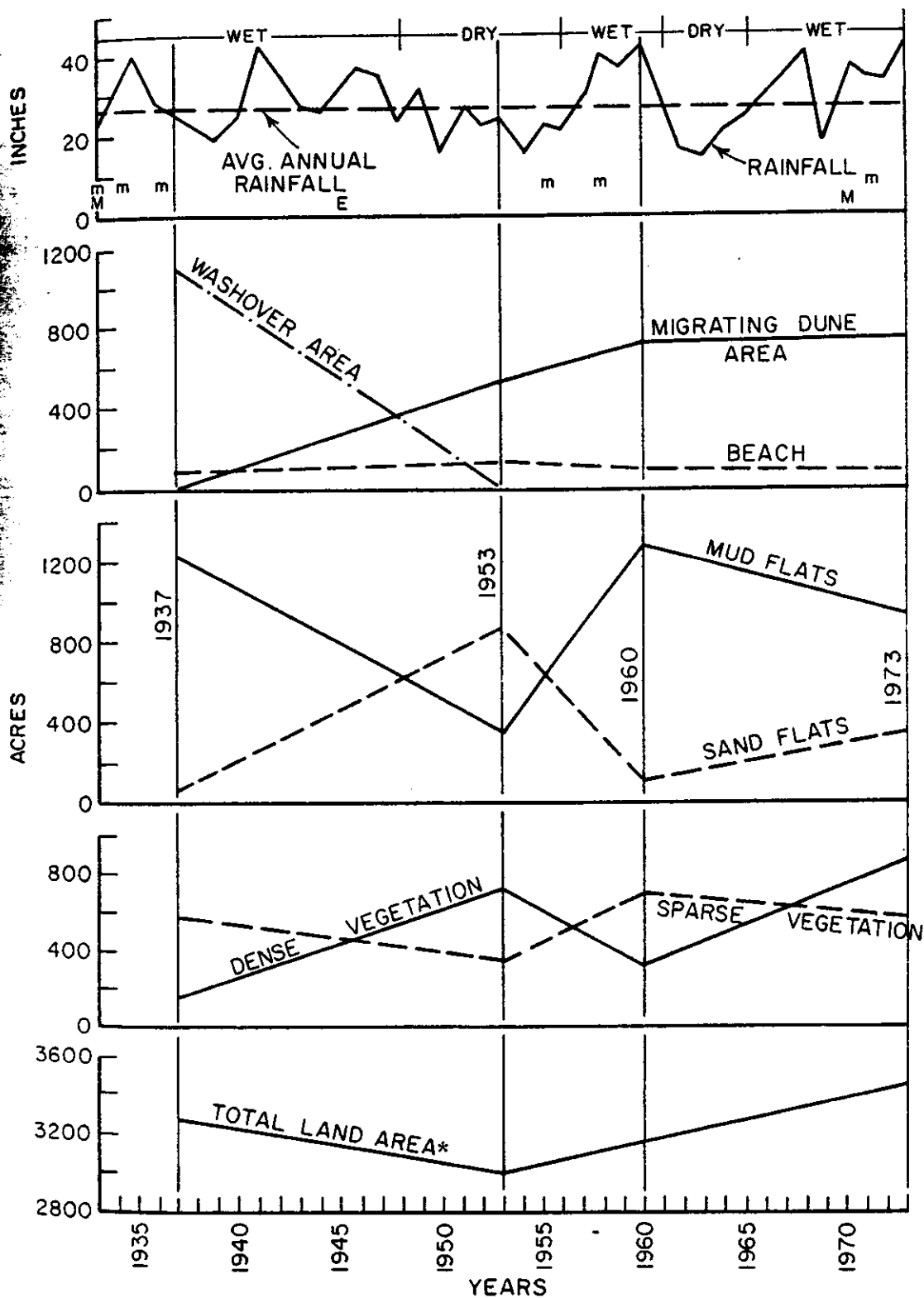
Figure 7. Rainfall, hurricane activity and environmental changes.

Hurricane data is for storms passing through the Padre Island area from 1933 to 1973 with maximum winds greater than 74 m.p.h. (from the Bureau of Economic Geology, personal communication).

<u>Intensity</u>	<u>Maximum Winds</u>	<u>Minimum Central Pressures</u>
Minimal(m)	74 to 100 mph	29.03 to 29.40 in.
Major(M)	101 to 135	28.01 to 29.00 in.
Extreme(E)	136 and higher	28.00 in. or less

Environmental data applies to the 3400 acre study area. Measurements taken with a planimeter from environmental geologic maps, Figure 10, p. 30. (original research).

Rainfall data from R. E. Hunter and K. A. Dickenson [22] and U.S. Department of Commerce, NOAA, climatological data, Corpus Christi, Texas.



* Changes in total land area are due to beach regression and progradation of the back island wind tidal flats.

Economics

Economics has been described by Hite and Laurent [18] as "the science of values and choices." Economics in the coastal zone is primarily interested in the allocation of resources to the optimum benefit of the users of those resources. Many questions arise as to the proper use and allocation of these resources which cannot always be answered by purely economic analysis.¹⁴ However, relevant economic criteria can be established which account for those areas in which current methods of economic analysis fall short, and these criteria can then be used to establish a more efficient system of evaluation.

The economic factors considered here are risks, uncertainties, externalities, value, price, and cost. Each is relevant and requires definition. In the discussion to follow these factors are examined in the context of barrier island development and the proper allocation of resources.

Risk and uncertainty are related in that both refer to possible events in the future which may result in loss (or gain). Risk is distinguished from uncertainty in that the former refers to events for which statistical measures can be calculated because of the availability of reliable data. For example, given accurate data on the

¹⁴ A thorough discussion of the problems associated with coastal zone resources and market allocation is given in D. W. Ducsik [7].

frequency and intensity of storms, including hurricanes, for a barrier island, one might calculate the risk of loss incurred in buying and also building (depending upon structure and specific location) on the island.¹⁵ One only predicts the chance, of course, not the timing of the event.

Uncertainty, on the other hand, refers to events which simply cannot be predicted on the basis of past experience. Man-made alterations to the mainland coast may produce unpredictable results on barrier islands.

In actuality, risk and uncertainty tend to shade into each other.¹⁶ While our historical data may be imprecise we can still predict that it would be riskier to build a structure on the beach of a barrier island than behind the foredunes, since the beach bears the brunt of hurricane forces.

¹⁵ Storm frequency on the Texas coast is often referred to as one every seven years, representing a 14% risk of storm attack to coastal developments each year. The data in Figure 7 (p. 15) reveal that from 1933 to 1973 the frequency of tropical cyclones attacking Padre Island was one every four years. Therefore, a twenty-five percent risk per year of storm attack might be assumed by property owners on the island. Commonly, however, risk is calculated for the 100 year storm. This is the procedure used by the government in the National Flood Insurance Program [27] where the minimum first floor elevation of residences qualifying for flood insurance must be above the 100 year flood level. The corresponding risk of flooding in any one year is approximately 1%.

¹⁶ The implications of risk and uncertainty as described by J. Hirshleifer and D. L. Shapiro [17] provides additional insight into the relationship between these two factors.

Externalities are popularly referred to as "third party" or "uncompensated for" costs or benefits.¹⁷ Consider this situation: Party "A" buys a beachfront lot on the Gulf of Mexico and Party "B" buys the one behind him. Then Party "A" decides to build a 14 story highrise on his lot and pays Party "C" to build it. The third party, "B," in losing his view of the Gulf incurs a cost for which "A" does not compensate him. In this example, the externality deals with an amenity, view. "A" expands his amenities and in doing so imposes a cost on "B," whose amenities are reduced. Therefore, when dealing with externalities there is always one side that benefits at the cost of another.¹⁸ Externalities may be assigned a value although in practice this may be difficult to do.

Value is the general worthiness, importance, or usefulness of an item or entity as determined by the individual or party concerned. In other words, the same plot of land may have a different value to different individuals depending on his personal priorities, preferences, and tastes.¹⁹ Value may be, and often is, given a monetary worth, although this is not inherent in the definition.

¹⁷ Refer to H. H. Hinrichs [16] for a more thorough discussion of externalities.

¹⁸ The concept of externalities can be applied to society or nature as a third party. In such cases, costs and benefits are not so easily identified.

¹⁹ This brings to fore the issue of competing uses. One individual may value property for its mineral rights while another may value it for its amenities. The issues and arguments created by this type of situation are matters of great concern and debate in coastal zone management.

It is precisely because different people value the same item differently that transactions occur. If a buyer does not think an item is worth as much or more than its price he will not buy it, nor will a seller part with the item unless its price is equal to or greater than its value to the seller. (There are exceptions to this which can occur under extenuating circumstances.²⁰)

Market price is that price at which buyer and seller agree to exchange money for an item or for the use of an item (as in the case of rental or lease). Typically, land developers will stipulate prices for tracts of land depending upon size, location, and other factors, and expect to sell at these prices. Demand at such prices may be less than expected, however, and prices may be adjusted downward. Or conversely, higher demand may push prices up.

Cost, as referred to in this study, is the money outlay necessary to establish, create, erect, or maintain ones investment (a house, for example).

Geo-economic analysis attempts to incorporate these economic factors, some of which are not included in the present market allocation system, into a more efficient system of property evaluation. With these criteria clearly defined, let us now turn to another discipline deeply involved in the allocation of resources, that of management.

²⁰ For an enlightening discussion of some of these extenuating circumstances, refer to P. W. Barkley and D. W. Seckler [1].

Management

Management involves the use of resources to accomplish certain objectives. Given good objectives, good management requires judicious use of resources. The management of natural resources has, patently, not always been judicious. To achieve good management one must first identify the resources with which he is working; second, determine the system within which he must work; and, finally, establish a mode of allocation through which the judicious use of resources can be optimized.

The resources of Padre Island can be conveniently catagorized as mineral, vegetable, or animal. And, in a broader sense, all of these resources combined represent a unique resource, the barrier island.

The important mineral resources of Padre Island are of two types, surface sediments and subsurface hydrocarbons. The surface sediment, sand, is valuable as aggregate used in construction. Subsurface hydrocarbons, mainly natural gas, are, of course, a very valuable energy resource. Both of these resources are non-renewable,²¹ and therefore, the allocation and use of these resources must be approached with extreme caution so as not to reduce future options.

²¹ Some may argue that sand is in effect a limitless resource; however, one can certainly see that within the geographic boundaries of Padre Island if all surface sediments were mined out, there would no longer be an island, and hence future utilities of this resource as well as the other island resources would be reduced to zero.

The vegetable resources of Padre Island include algal mats, sedges, and low-lying vines and shrubs. Any sort of vegetative cover is vitally important to the barrier island complex as it serves as a kind of life-support system to the island by obstructing the path of wind-blown sand and stabilizing the surface sediments, thereby sustaining the fragile equilibrium within which the island exists. Removal of vegetative cover encourages erosion and jeopardizes the subsistence of the barrier island complex. On the other hand, extensive planting of beachgrass may also increase erosion [30]. Studies conducted by the National Park Service on Cape Hatteras found that a continuous, stabilized, dune wall did not allow the natural flow of water over the island during a storm and actually increased beach erosion.

Washover areas perform a necessary function. They allow water to pass over the island during high storm activity, relieving the beach of the full brunt of wave forces and thereby increasing the island's flexibility, enabling it to regenerate itself after the storm passes. The interdependence between and among these island environments should, by now, be obvious. If it is the objective of planned management to preserve and protect the investments on the island, it should be their responsibility to see that these natural systems continue to function normally.

In its natural state, two centuries ago, the vegetation on Padre Island was lush and dense [34]; but when man introduced cattle,

horses, and sheep to the island, the first changes occurred. The first attempts by man to manage this island wilderness as rangeland resulted in overgrazing, denuding the island of its natural protection, and leaving a vast expanse of wind-blown sand.²² Today, the National Park Service manages most of Padre Island. The cattle have been removed and the vegetative cover, although still sparse, is now struggling to re-establish itself, and with it, the island's natural equilibrium.

The sea is, without doubt, the coastal zone's most important resource. Perhaps the most important use of this resource on Padre Island today is as a site for recreation. The Gulf of Mexico draws thousands of visitors from all over the United States to the vast open shores of Padre Island each year. It follows that tourism is a large, economic factor providing employment for many of the residents of the coastal zone who in turn provide the goods and services these tourists require. However, recreation, as all other uses, must compete for the allocation of these resources. The oil and gas industry, fisheries, transportation, public utilities, housing, conservation, and recreation all compete for the use of this unique natural resource.

²² Early in the nineteenth century, the man after which the island is now named, Padre Bali, was the first white man to successfully establish a homestead on Padre Island. For a more detailed description of the island's early invaders and these first attempts at ranching, refer to V. Smylie [34].

Some of these uses are compatible, some are displaceable, and some, such as preservation, require exclusive use of the resources.²³

No "sure-fire" method of establishing which uses have priority has been or perhaps can possibly be established. One thing is for sure. The system that we must work within in determining the use of these resources is complex.

One major problem in coastal zone management is the dispersion of powers. Federal, state, county, city, and a seemingly infinite multitude of special purposes districts all have jurisdiction over different and overlapping areas throughout the coastal zone. Each has its own policies, objectives, and strategies in achieving its own goals. Add to this the separate set of policies, objectives, strategies and goals established individually by each of a myriad of private industries that have specialized interests in the coastal zone, and the present market system of allocation through which each of these operates, and one has a situation bordering on chaos.²⁴

Geo-economic analysis does not attempt to resolve this problem. But it addresses itself, instead, to a more tangible and equally

²³ For a more detailed discussion of compatible, displaceable, and exclusive use, refer to B. H. Ketchum [24].

²⁴ Working within this array of diverted interests has been appropriately summed up by Dr. Robert Stevenson as "the management of conflict" [36].

significant problem, that of market pricing, which, in the end, is a determinant in the allocation of these properties.²⁵

²⁵ Market pricing is a determinant in the allocation of these properties because it delimits the sector of potential users by establishing prices that are beyond the means of lower income groups as well as the public as an entity (i.e., as an entity the public is a potential buyer for such things as public beaches, parks, and recreational areas). Land at these prices can only be competitively marketed to industry, commercial developments, and private housing and recreation for those who can afford it.

THE STUDY

Any evaluation should satisfy at least three requirements. It should (1) identify criteria, (2) recognize the issues, and (3) offer an alternative means of contending with the issues involved. An evaluation does not give "the answer." However, it should utilize new tools and a fresh approach to problem-solving. This study investigates the utility of geo-economics²⁶ in recognizing additional factors to be given consideration in placing value on property being developed.

Geo-economics simply incorporates geologic information into an economic analysis of barrier island property development. The objective is to internalize economic externalities and account for economic risk and uncertainty created by natural geologic processes. Presently, because of market failure (i.e., externalities), some uninformed buyers pay exorbitant prices and at the same time absorb high risks. For example, consider the development scheme illustrated in Figure 8 (p. 26). A developer has purchased 200 acres of barrier island property including sand flats, mud flats, vegetated flats, and part of a washover fan. He figures that in order to make his investment pay off, he must get a return of \$800,000. So, he has subdivided the land into 40, 5 acre lots which he intends to market at

²⁶ The term geo-economics has been coined by the author as a shorthand notation to describe the analytical approach presented in this thesis.



Figure 8. Hypothetical development subdivision.

\$20,000 each. To an uninformed buyer, one lot may look as attractive as the next, or perhaps a lot on the washover fan may appear more attractive because his view of the beach is not obstructed by the foredunes. If the buyer does in fact purchase a lot on the washover fan, he will be paying an exorbitant price and incurring high risk. What he obviously overlooked is that his property will be more subject to storm related destruction than will his neighbors' behind the foredunes. He has realized a negative externality because he paid the same price as his neighbors behind the foredunes but he is not provided the same safety. On the other hand, his neighbors realize a positive externality, the additional safety of the fore-

dunes, at his expense.²⁷ A case study of a hypothetical land development on Padre Island will be used to further illustrate the application of geo-economics.

The hypothetical development site is located in the vicinity of Yarborough Pass (27° 12' 30" N. lat., 97° 22' 30" W. long.), Figure 9 (p. 28). The area is typical of barrier islands on the Texas Gulf Coast, and is representative of lands located anywhere from Galveston to Port Isabel. Approximately thirty-four hundred acres of land are considered in this investigation for a proposed residential and recreational community.

The geo-economic analysis is composed of four parts: (1) preliminary site investigation, (2) laboratory analysis, (3) data reduction, and (4) conclusions. The site investigation is preceded by a literature search. The literature search includes a survey of previous geologic publications, a collection of maps, and correspondence with geologists familiar with the site under investigation. The preliminary site investigation should be brief. It can be completed in a few days when performed by a competent geologist or engineering geologist. The intent is to observe geologic features

²⁷ Consider another case, where the seller decides to market land on the washover at a higher price than land behind the foredunes because it offers an unobstructed view of the Gulf. In this example, the buyer of washover property may soon find that he loses his unobstructed view as the washover is stabilized with vegetation and the foredunes are regenerated. Again, the buyer has suffered a negative externality; as in the example on p. 18, he lost his view of the Gulf without compensation. However, in this case the externality was due to natural processes.

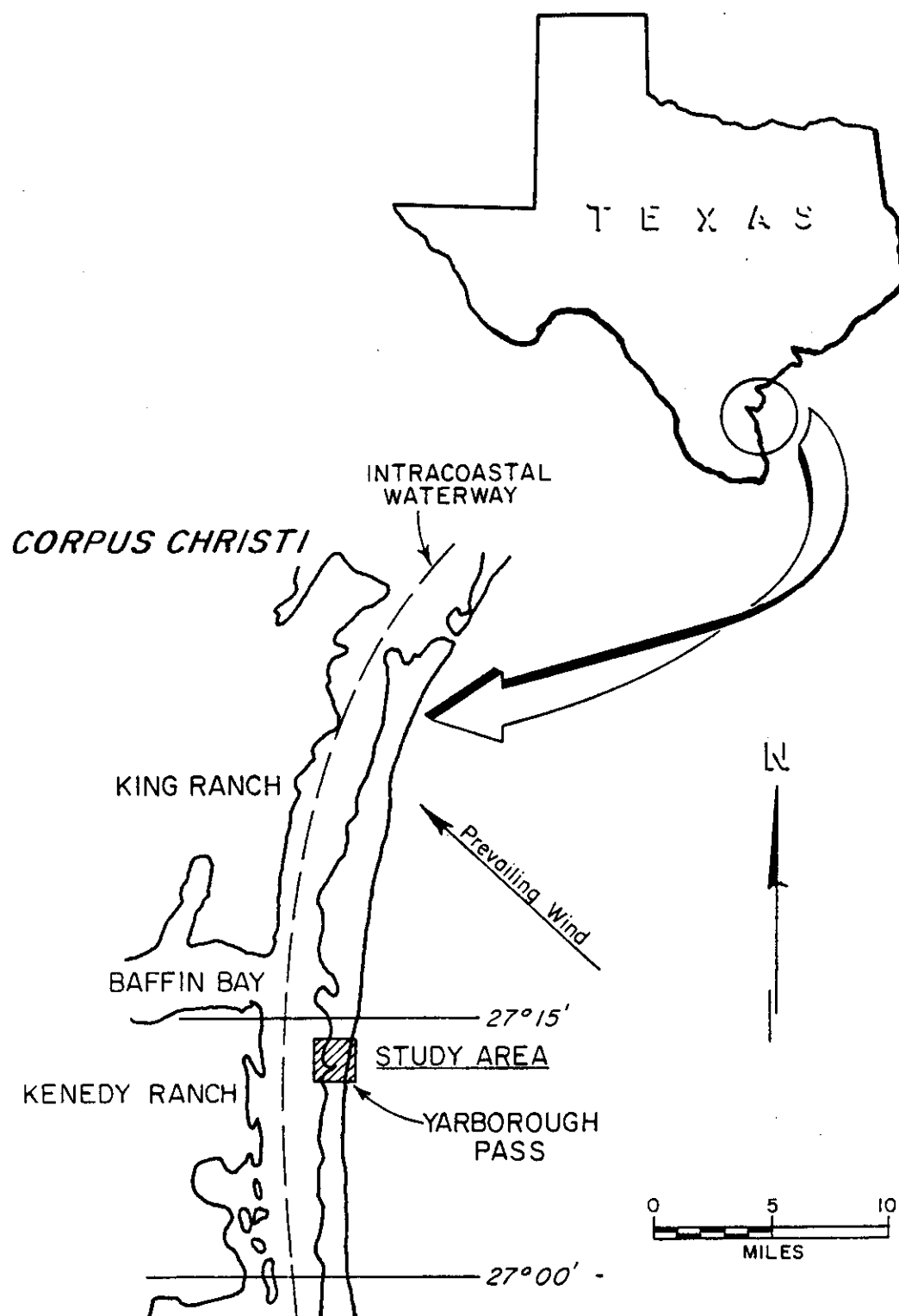


Figure 9. Map of Texas, showing the location of the study area.

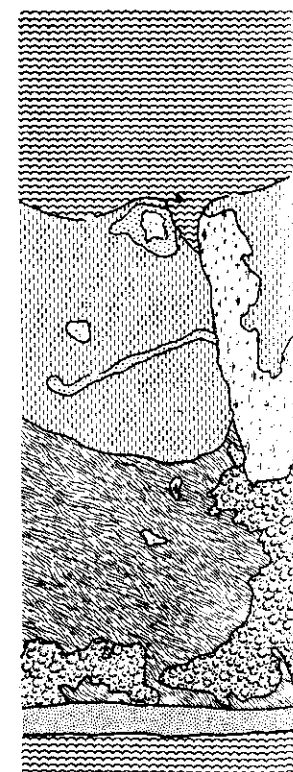
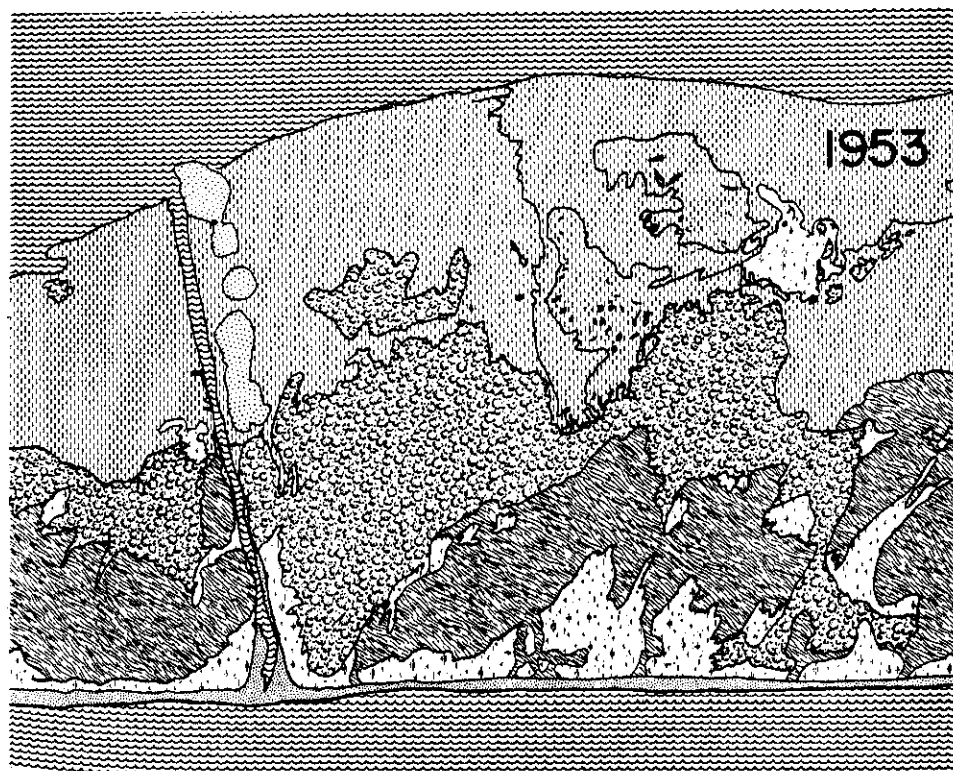
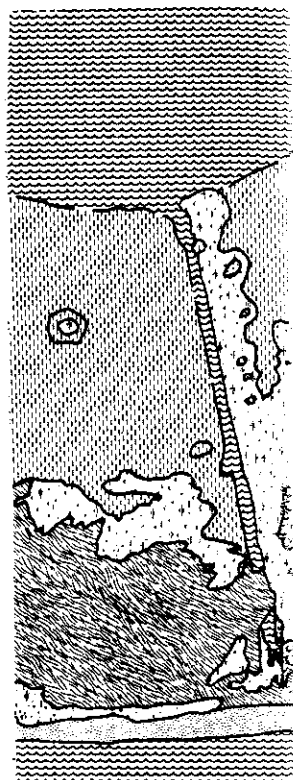
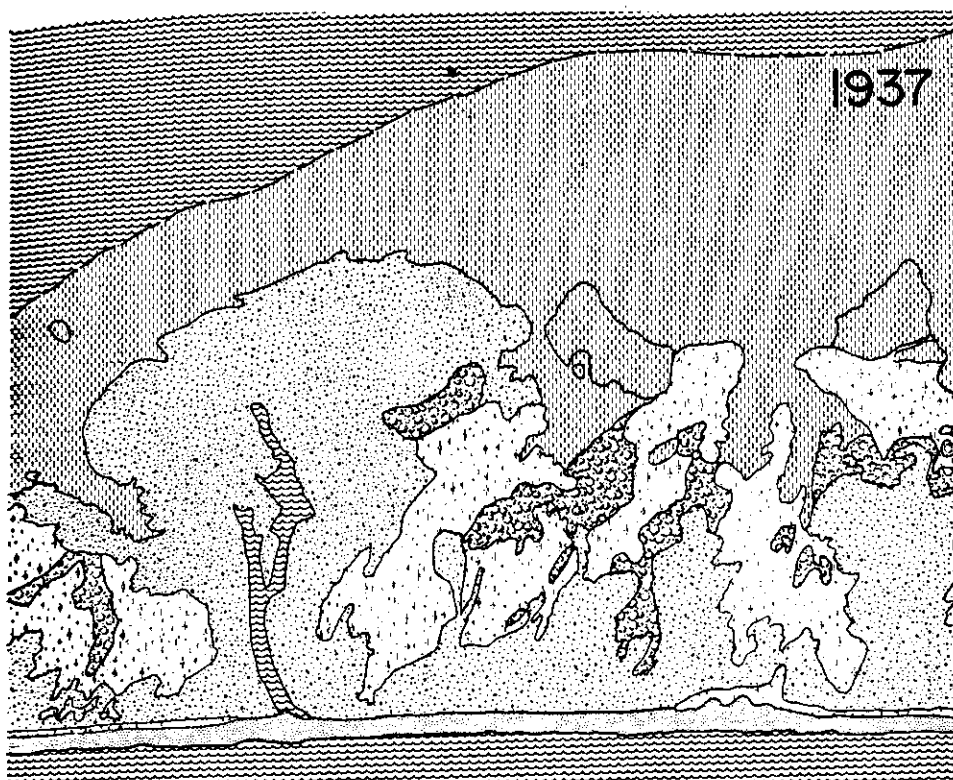
peculiar to the area. Notes, samples, sketches, and photographs should be taken to note distinguishing characteristics as was done by the author on Padre Island in May 1974. The preliminary site investigation lays the groundwork for laboratory analysis.

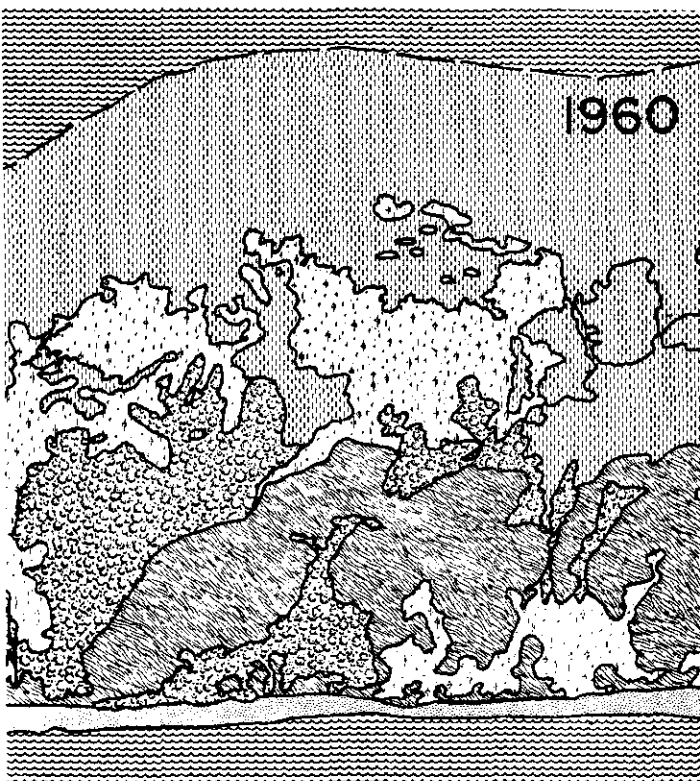
The laboratory analysis consists of an environmental reconstruction of the area through the use of historical maps, aerial photographs, and reports which can be presented in map form. In this study, eight different geologic environments were mapped²⁸ from aerial photographs taken in 1937, 1953, 1960, and 1973, illustrated in Figure 10 (p. 30). Comparison of the maps reveals environmental changes and provides a method whereby geologic dynamics can be monitored.

This geologic data can then be reduced, using matrices, to a form that can be utilized in geo-economic analysis.²⁹ Each column of the matrices represents a different environment in which the proposed development may take place. Each row depicts a different risk or cost associated with the investment in the development. The numerical value assigned to each box corresponds to a particular row and

²⁸ The eight geologic environments mapped are: (1) water, (2) beach, (3) dense vegetation, (4) sparse vegetation, (5) banner complexes (migrating dune fields), (6) wind tidal flats, (7) washover areas, and (8) spoil areas.

²⁹ The utility of matrices for data reduction and evaluation has been well illustrated in several recent studies. Among those are J. C. Hite and E. A. Laurent [18], L. F. Brown, Jr., et al. [2], R. H. Twiss and J. C. Sorensen [37], R. H. Ellis [9], C. G. Groat and L. F. Brown, Jr., [13], and L. B. Leopold, et al. [25].





-  WATER
-  BEACH
-  BANNER COMPLEX
-  DENSE VEGETATION
-  SPARSE VEGETATION
-  WIND TIDAL FLATS
-  WASHOVER AREAS
-  SPOIL AREAS

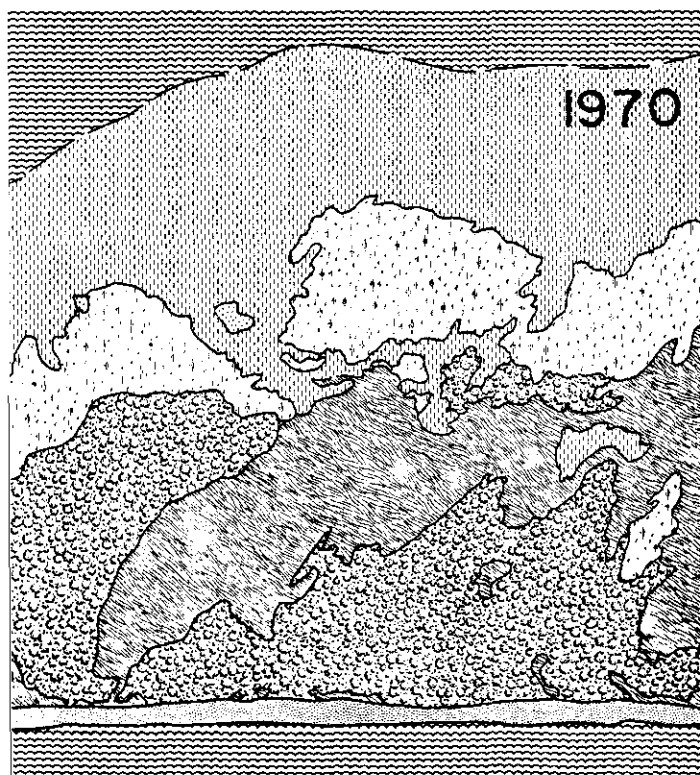


Figure 10. Environmental Geologic Maps of the Study Area

column, and is indicative of the relative degree of risk or cost (depending on the matrix) associated with a development within the environment indicated. By assuming all developments on the island are of the same type and by figuring all risks and costs over a thirty year period for these developments, a rational comparison of the numerical values in the matrices can be performed both horizontally and vertically. Individual numerical values were assigned according to the best factual estimates available so as to reduce subjectivity. Justification of individual assigned values will be provided in the discussion below.

The first matrix relates the probability of storm wave attack, flooding, sand accretion, erosion and other catastrophic events to each environment. A value of 5 represents the highest risk; 3, moderate risk; 1, low risk. These data, transferred to a graph, illustrate the relative economic risk associated with development in each of the environments, Figure 11 (p. 32). Since the numerical values in the matrix are comparable both horizontally and vertically, these data can be transferred directly to a graph simply by summing the values in each column and assigning the total value to the corresponding environment.

The risk of storm wave attack is greatest near the Gulf and decreases away from the Gulf. Although the waters in Laguna Madre are normally shallow, high storm tides and high winds were considered significant enough to assign a value of 4 to the lagoonal

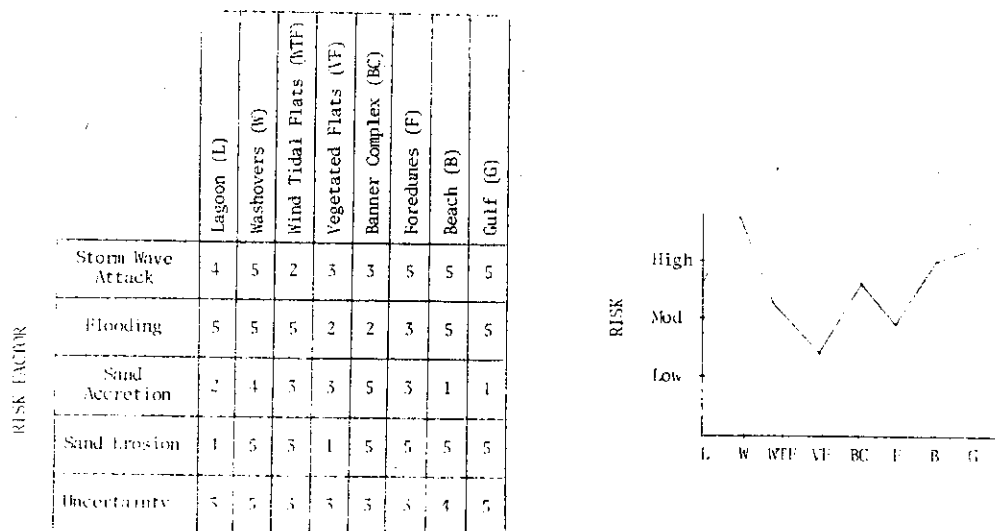


Figure 11. Matrix and graph of the risk factor.

environment. Washovers are low-lying areas and are as vulnerable to storm wave attack as are the beach and foredunes. Correspondingly, a value of 5 was assigned these areas.

Low-lying areas and areas adjacent to the water are most likely subject to flooding. The banner complexes and vegetated flats within the study area occupy relatively high ground, and so values of 2 were assigned to these areas.

Areas vulnerable to sand accretion that might be hazardous to a development are only those areas within or immediately adjacent to washovers and migrating dune fields. Therefore, these areas were assigned high values, 4 and 5 respectively; adjacent areas were

assigned intermediate values; and the Gulf, beach, and lagoon were assigned low values.

Areas vulnerable to storm wave attack are also subject to erosion. Hence, high values were assigned to the Gulf, beach, fore-dunes, washovers and lagoon. In addition, areas not covered by vegetation may be scoured by wind-blown sand, particularly those areas within banner complexes. It follows that the vegetated flats should be assigned a low value, 1, the wind tidal flats a higher value, 3, and banner complexes, the highest value, 5.

Uncertainty, by definition, cannot be predicted. However, it seems logical that those areas directly adjacent to the sea and subjected to the dynamic forces of the ocean would carry the highest degree of uncertainty and those areas removed from the water would have a lower degree of uncertainty. Thus, numerical values were assigned accordingly.

The results computed from these data indicate that the vegetated flats carry the lowest risk, adjacent areas a moderate risk, and the Gulf, beach, and washover the highest risk; foredunes, banner complex, wind tidal flats, and lagoonal areas propose a moderately high risk to development.

The second matrix relates foundation, construction, access, maintenance, and external costs to each environment. When transferred to a graph, these data reflect costs and externalities associated with development in each environment, as illustrated in Figure 12.

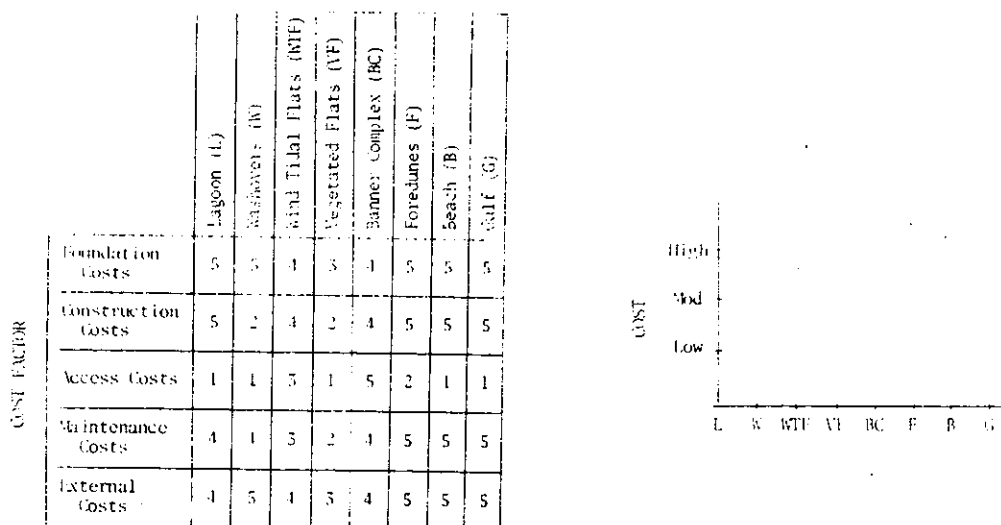


Figure 12. Matrix and graph of the cost factor.

Foundation costs include those costs associated with driving piles, platform construction, and reinforcement. High foundation costs in(on) the Gulf, beach, foredunes, washovers, and lagoon result from (1) special design requirements, (2) additional reinforcement, or (3) extra equipment costs necessary to complete a foundation in these areas that would not be required in the vegetated flatlands, banner complexes, or wind tidal flats. Some additional design and equipment costs might be expected in the banner complex and wind tidal flats that would not be expected in the vegetated flats; however, these costs would probably not be as great as those in the other areas.

All costs of completion outside of foundation and access costs are included in construction costs. Extreme costs in(on) the Gulf, beach, foredunes, and lagoon may result from (1) bulkheading, (2) dike or seawall construction, (3) fill, (4) hazardous or difficult working conditions, (5) additional equipment costs, (6) special design or reinforcement, or (7) the installation of utilities. Additional but not extreme costs might be incurred in the banner complexes and wind tidal flats due to difficult working conditions, fill, or added utility installation costs.

The cost of access is meant to include those costs necessary to maintain guaranteed access. For example, in order to guarantee access to the wind tidal flats it would be necessary to elevate roadways or dredge channels, and additional expenses would be required to maintain these thoroughfares. Extreme costs would be required to maintain a safe thoroughfare through the dune fields as this would require persistent removal of wind-blown sand (a task that is more or less futile). Some additional costs would be experienced by the owners of foredune developments as it would be necessary to erect elevated boardwalks or roadways since the dunes cannot withstand even light abuse.³⁰

³⁰ Elevated boardwalks over the dunes increase the wind stress field over the dunes and reduce the sunlight needed by the stabilizing vegetation on the dunes, and therefore initiate erosion. Additional external costs would be incurred by the property owner in order to maintain the foredunes.

Maintenance costs involve all expenditures made after construction as required by normal upkeep. Extreme costs would be absorbed by homeowners in(on) the Gulf, beach, and foredunes due to accelerated weathering caused by the ever-present salt spray and an increased vulnerability to storm activity. Additional expenditures would be required for maintaining structures in the banner complexes because of exposure to wind-blown sand and the removal of such deposits. Additional costs might also be expected in(on) the lagoon and washovers due to occasional storm damage so a value of 4 was assigned to these areas.

External costs are those that are experienced by the buyer that are not included in the four above categories and may be inflicted upon the buyer by no action of his own. The example given previously about property on the washover would also apply to Gulf, beach, and foredune owners, and to a lesser extent owners of banner complex and wind tidal flat property. External costs realized by homeowners in the dune fields or wind tidal flats may result from negligence on the part of neighbors in their immediate vicinity (if they have any) who do not maintain or protect their developments as they should.

As indicated in the graph on page 34, Figure 12, high costs would be imposed on developments in all areas except the vegetated barrier flats where costs are relatively low. From this graph and the graph in Figure 11 (p. 32), true land value or geo-economic value can be computed. Since value is high where costs and risks are low,

and low where costs and risks are high, the value curve is obtained by taking the average of the cost and risk curves and inverting it on the same vertical scale, as shown in Figure 13 below.³¹ This curve is quite different from that shown in Figure 14 which portrays present value as determined by the market system.³²

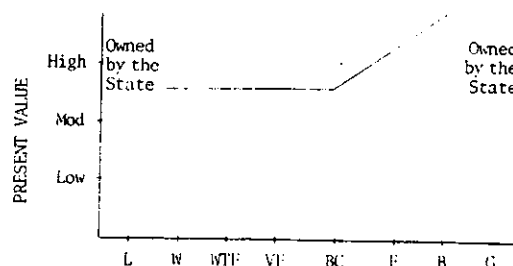
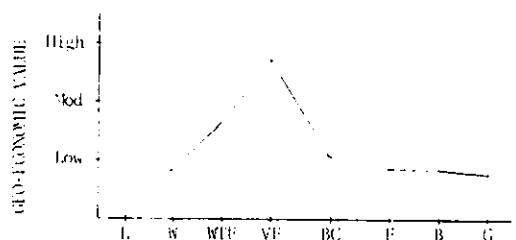


Figure 13. Geo-Economic Value

Figure 14. Present Value

Some important issues arise out of this discrepancy. (1) Is the instability of barrier island environments a natural phenomena which can be ignored in barrier island property development? (2) Will this

³¹ The results obtained by this method are directly supported by the recommendations which came out of the study on resource capability units done by L. F. Brown, Jr. et al. [2].

³² The data collected to establish the curve shown in Figure 14 was obtained through separate personal interviews with a real estate broker and a developer on South Padre Island, referenced earlier in footnotes 1 and 3.

instability be further aggravated if island properties are not managed properly? (3) Should effective management consider risks, uncertainties, and externalities in determining values and subsequently price in land development on the island? (4) Should a public policy be developed and implemented through appropriate legislation to regulate and restrict development of barrier island property so that the risks, uncertainties, and externalities will be made known to those buying and selling these properties for their use in determining value? The following discussion will be directed toward these issues.

DISCUSSION

The results provided in the previous discussion can be used by the reader for his own evaluation. The intent of this discussion is to summarize the issues and provide possible solutions to these issues. It is not intended that these solutions apply to all developments along the coast nor that the restrictions forwarded are absolute. More so, it should be realized that this discussion is directed toward the study area, previously described, and that the opinions derived by the author are based on the factual information collected within this study area. The examples used may not be applicable to coastal developments in other areas but are representative of the dynamics of barrier island environments in general.

The first issue concerns the instability of barrier island environments and property development. It has been shown that barrier island environments are extremely dynamic, that they vary from place to place and from time to time on the island. Moreover, it has been shown that if 100% of the island area is developed, certain areas will incur higher costs and greater risks than others. Therefore, it is of advantage to the property buyer to be aware of these areas which are potentially hazardous to development. Three areas are worth particular recognition with respect to environmental hazards.

Washover areas are probably the most hazardous areas to develop in. These areas provide a natural channel through which high storm

waters may pass. Developments in washover areas are exposed to intense storm activity. Attempts to construct seawalls or artificial dunes in these areas may result in additional destruction elsewhere. Therefore, this type of development should be restricted. At least three options are open to a developer who owns property on a washover. One, he can claim a moratorium on the area; hope that the area will not be subjected to further storm destruction; and wait for vegetation to stabilize the surface sediment and regenerate foredunes before re-opening the area for development. In the study on Padre Island, re-vegetation began almost immediately after the storm period had passed, and sizeable foredunes (15 to 30 feet in height) were generated in 15 years. Two, he can open the area for development immediately, but he should implement precautionary design and construction requirements on all structures within the area so they will not be lost to storm washover. Three, he might attempt construction of a seawall or artificial dune wall at the risk of increasing erosion in adjacent areas and a potential lawsuit connected with this action.

The beach is an extremely hazardous area to develop in. In this study, beach erosion was in excess of 300 feet over the 36 year period of observation. The average annual erosion rate was approximately 10 feet per year. To insure a safe life of thirty years for coastal structures, a setback line of at least 300 feet from mean high tide should be observed. This, however, would allow

for development on the foredunes. Although foredunes do not in themselves present a hazard to development, development on the foredunes would be hazardous to the environment. Foredunes provide natural protection for the island against storm wave attack. During intense storm wave activity the foredunes may be destroyed, but they would normally regenerate once the storm has passed. If this natural protection is removed or diminished because of development, further destruction is liable to occur in other areas which were previously protected by the foredunes. Low-lying areas unprotected by foredunes are subject to frequent storm washovers. Hence, the foredunes should be preserved and a setback line should be established to include the foredunes. It is necessary to recognize that as the beach regresses, so will the foredunes; consequently, the setback line should allow for this natural regression of the foredune ridge (i.e., the line should be set 300 feet beyond the present line of foredunes).

Banner complexes also impose environmental hazards on developments. These areas are not directly exposed to storm related destruction, but because of the natural migration of sand across the island, developments in these areas would be exposed to a day to day threat of inundation by encroaching sand dunes thirty to fifty feet in height. Attempts to fortify against encroaching sand dunes are both economically and physically futile. Therefore, development in banner complexes should not be allowed. The migration of active

dune fields within the study area has been measured at 100 feet per year westward and 10 to 20 feet per year to the north. If these dune areas are allowed to migrate freely, developments considered safe having a thirty year life could not be located within 3,000 feet to the west nor 200 feet to the north of the banner complexes, and it would be necessary to establish setback lines accordingly. An alternate approach to development might undertake the mining of these sands at the western and northern perimeter of the complex as it migrates; thereby providing protection against sand encroachment in these directions and allowing for safe development in otherwise hazardous areas. In this example, setback lines would not be necessary. Another option open to the developer might be to mine sand directly from the mouth of the chute and eventually close off the chute so that sand from the beach would never reach the dune complex. It would then be necessary to vegetate the loose sand area before structures could be erected; however, this scheme would probably be financially prohibitive. Because the potential deleterious effects on the island caused by altering the natural processes are unknown, development along these lines should be approached with great caution and preceded by a thorough environmental impact study.

The second issue addresses itself to the potential hazards of improper management. This is specifically concerned with the environmental effects of development. Any time development begins in an area that has previously remained undeveloped, future environmental trends

may be expected to vary significantly from those indicated by past trends observed through historical environmental geologic mapping (as was conducted in this study). Developments behind the foredunes, in the past, have increased barrier island stability due to the additional vegetative cover (St. Augustine or Bermuda grass) added by the land owner for aesthetic reasons. On the other hand, developments seaward of, on top of, or in place of the foredunes have not met with great success in achieving stability.³³ An investigation of critical erosion areas, costs and effects of improvement, and developments along the Texas coast has been conducted by the Army Corps of Engineers [6]. It is necessary to note that the original development of virgin areas will always be accompanied by a high degree of uncertainty with respect to environmental effects. Three points, previously discussed, are worth reiteration. Of primary importance is the preservation of the foredunes. Secondly, the potential hazards related to the construction of seawalls or artificial dunes in washover areas, as discussed on pp. 40-41, should be considered before construction begins. Thirdly, attempts to alter or confine natural environmental processes, such as mining the dune fields, should be avoided unless additional information indicating that such attempts would not be deleterious to the environment has been provided through specifically related studies.

³³ Appropriate examples include the developments on Sargent, Bryan, and High Island beaches in Texas.

The above discussion has concentrated on restricting development. It is not the intent of this study to advocate excessive restriction nor excessive development. Therefore, it is necessary to consider the effects of restriction on development and to establish the best possible mix. The third issue considers the implications of accounting for risks, uncertainties, and externalities in determining values and prices of land development. Anytime restrictions are imposed on the developer, he will experience additional costs which must eventually be passed on to the buyer. In a particular case, the restrictions related to development within and adjacent to banner complexes may reduce the developable area by fifty percent or greater. The developer has two choices. One is to resort to high density housing, condominiums or highrises, in the developable area which will permit him to gain the additional income necessary to make his investment profitable. An alternative mode of development might call for instituting environmental precautions, such as mining the sand, in order to increase the area he can develop and still profitably market single family unit housing. In either case, the price of land will necessarily be increased due to the imposed restrictions. However, this increased cost is justified by a reduction in the risks, uncertainties, and potential externalities in the investment. In a different situation, accounting for these economic factors might reduce the buyer's initial cost.

Consider the 200 acre development on the washover fan described in Figure 8 (p. 26). In order to account for risks, uncertainties, and externalities, the developer must recognize the additional hazards associated with development on the washover fan. Therefore, the developer may choose to reduce the cost of land on the washover fan since its geo-economic value is not as high as that of properties protected by well established foredunes. In doing so, he would be forced to increase the price of land behind the foredunes, but he would have effectively internalized the externalities associated with the development (as discussed on p. 26). The buyer's initial costs are reduced, but additional foundation, construction, and maintenance costs would absorb the remainder of his savings. Assume the developer decides to develop only those areas outside the washover fan and to retain the area within the washover as a private club or recreational facility. He would be able to boost the market price of his development because of its exclusive attractions. This mode of development is equally effective in accounting for risks, uncertainties, and externalities. However, these schemes will work only if all developers in the area also account for these hidden costs in a comparable manner.

The fourth issue is concerned with the implementation of legislation to insure that buyers and sellers are aware of the risks, uncertainties, and externalities associated with barrier island property development. This is an issue that cannot be resolved

simply by the observations of one author; however, it should be discussed because this issue integrates and makes real the implications of the other issues involved. Legislation, in itself, provides no real answer to the problem. It is the implementation and enforcement of good legislation that makes it successful or self-defeating. Often times, the issues can be resolved simply by making those involved aware of the problems they face. However, this is not always possible. In this case, a call for legislation to insure that those involved will be informed of the potential hazards of development seems only fair. This certainly was the intent of the Interstate Land Sales Full Disclosure Act. However, the exemptions of ILSA effectively provide loopholes whereby full disclosure can be avoided. Amending these exemptions would alleviate the necessity to pass further legislation. The issue may be more in the implementation of legislation requiring developers to incorporate risks, uncertainties, and externalities into their evaluation of barrier island property. Reasons why such legislation should be passed are (1) it would provide protection to the buyer, (2) it would provide for more reasonable and safer developments, (3) it would protect the environment, (4) it would reduce the cost of hurricane insurance and flood protection, and (5) it would provide for a better allocation of our coastal resources. Reasons why such legislation might be avoided are (1) it would increase the costs and responsibilities of the developer, (2) it would increase prices in some cases, and (3) it would further

reduce the developer's autonomy over development. If our goal in coastal zone management is the judicious and equitable allocation of resources, then the passage of such legislation would seem imperative.

Barrier islands are unique and unusual areas that present peculiar problems to housing developments. A stringent analysis of the potential hazards and resulting costs should be conducted before properties are offered on the market. Development unresponsive to risks, uncertainties, and externalities may prove hazardous to both the buyer and the environment.

CONCLUSIONS

At a time when the allocation of scarce resources is becoming increasingly important, all available tools should be utilized in decision-making. Geo-economic analysis was created as an additional tool to be used in the evaluation and allocation of barrier island property. The market system of allocation does not consider risks, uncertainties, and externalities in determining price. Geo-economic analysis provides an efficient means of incorporating these economic factors into property valuation. The analysis is sensitive to both environmental and developmental concerns. It can be used by private, public, and corporate entities to weigh and measure the security of their property investment. In addition, geo-economic analysis can be used to establish guidelines for development.

Certain areas on barrier islands must be considered hazardous to development. Geo-economic value indicates the suitability for development within each environment. The beach, washover fans, and banner complexes have a low geo-economic value. The vegetated flatlands are most desirable for development as the geo-economic value of this area is highest. In the allocation of barrier island property, other factors must be considered besides geo-economic value. Natural geologic processes and environmental trends may change the suitability as portrayed by geo-economic value. Therefore, a complete geo-economic evaluation must include (1) preliminary site

investigation, (2) laboratory analysis, (3) data reduction, and (4) conclusions.

Development on the beach and foredunes should not be allowed. Setback lines should be established behind the foredunes that are sensitive to beach erosion and foredune regression. Development in washover and migrating dune area requires precautionary measures or alternative modes of development. The options open to the developer are only restricted by the limits of safe architectural design and economic feasibility where additional risks or costs can be predicted. Geo-economic value can be used as an indicator for judicious allocation of barrier island property developments.

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