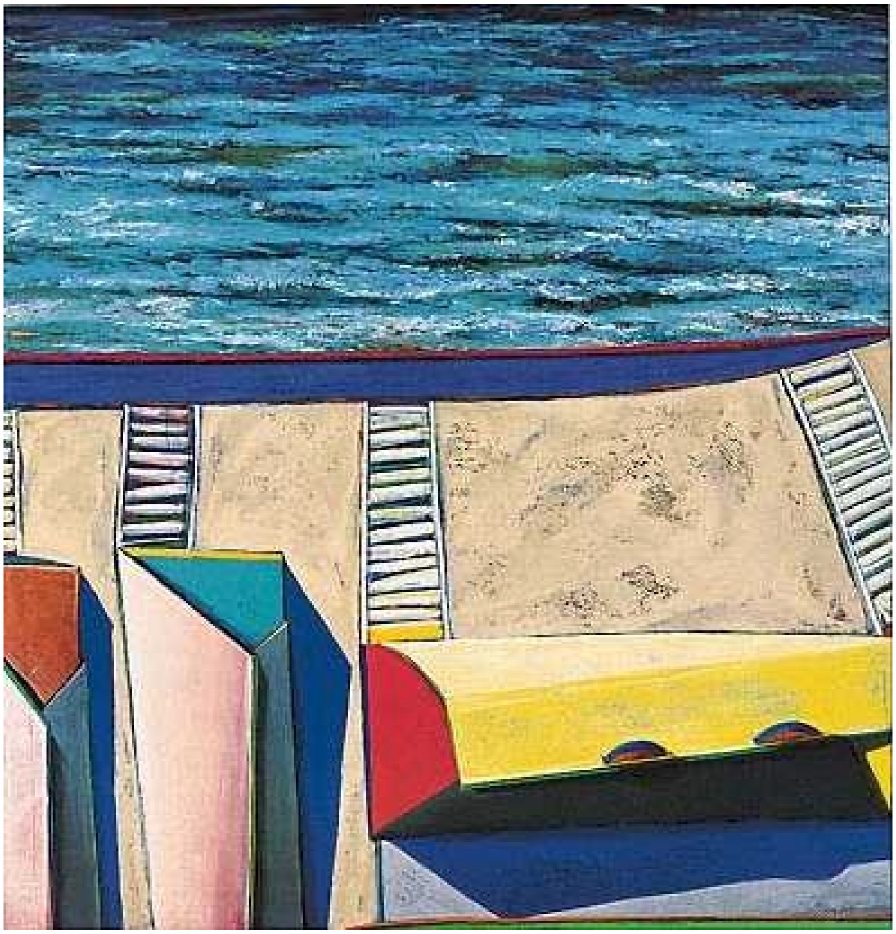
THE HEINZ CENTER

EVALUATION OF EROSION HAZARDS



April 2000

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The H. John Heinz III Center for Science, Economics and the Environment is a nonpartisan, nonprofit institution that furthers the work of Senator John Heinz by improving the scientific and economic foundation for environment policy. The Center's distinctive role is to engage and foster collaboration among industry, environmental organizations, government, and academia in each of its program areas and projects. Each of these sectors plays an important role in solving environmental problems, and each must participate in defining the agenda that shapes our common future. The Heinz Center provides an institutionalized venue for these sectors to work together on an array of diverse environmental and natural resource problems.

About The Evaluation of Erosion Hazards Study

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Cover art by Douglas K. Morris, Coastal Shadows No. 2.

Contacts
Federal Emergency Management Agency
Mark Crowell, Project Officer
500 C Street, SW
Washington, DC 20004
Phone 202-646-3432
e-mail mark.crowell@fema.gov

The H. John Heinz III Center
for Science, Economics and the Environment
Stephen Dunn, Deputy Project Manager
1001 Pennsylvania Ave, NW Suite 735 South
Washington, DC 20004
Phone 202-737-6307 Fax 202-737-6410
e-mail sdunn@heinzctr.org

EVALUATION OF EROSION HAZARDS

EVALUATION OF EROSION HAZARDS

A Collaborative Project of

The H. John Heinz III Center
for Science, Economics and the Environment

April 2000

Prepared for the Federal Emergency Management Agency
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EVALUATION OF EROSION HAZARDS

STEERING COMMITTEE MEMBERS

Stephen Leatherman, Chair, Florida International University, Miami, FL

Jeff Benoit, National Oceanic and Atmospheric Administration, Silver Spring, MD

Michael Buckley, Federal Emergency Management Agency, Washington, DC

Michael Colvin, Ohio Department of Natural Resources, Columbus, OH

Margaret Davidson, National Oceanic and Atmospheric Administration, Charleston, SC

Robert Friedman, The Heinz Center, Washington, DC

William Fry, Spatial Data Institute, Bethesda, MD

Robert Kates, Independent Scholar, Ellsworth, ME

Howard Kunreuther, University of Pennsylvania, Philadelphia, PA

Thomas Malone, Sigma Xi, The Scientific Research Society, West Hartford, CT

William J. Merrell, Jr., The Heinz Center, Washington, DC

Rutherford Platt, University of Massachusetts, Amherst, MA

Frank Reilly, Federal Insurance Administration (retired), Palm City, FL

Richard Roth, Sr., Actuary, Northbrook, IL

John Sawhill, The Nature Conservancy, Arlington, VA

V. Kerry Smith, North Carolina State University, Raleigh, NC

Gilbert White, University of Colorado, Boulder, CO

Robert White, The Heinz Center, Washington, DC

THE HEINZ CENTER PROJECT STAFF

William J. Merrell, Jr., Project Manager

Stephen V. Dunn, Deputy Project Manager

Robert M. Friedman, Vice President for Research

Sheila D. David, Fellow

Sarah K. Baish, Research Assistant

Allison Sondak, Research Assistant

COLLABORATORS

Joseph Cordes, Chair, Department of Economics, The George Washington University

William G. Fry, Spatial Data Institute

Andrew Keeler, Assistant Professor, Department of Agricultural & Applied Economics, The University of Georgia

Warren Kriesel, Associate Professor, Department of Agricultural & Applied Economics, The University of Georgia

Craig Landry, Doctoral Candidate, Department of Agricultural & Resource Economics, The University of Maryland

Susanne Moser, Senior Scientist, Global Resources Program, Union of Concerned Scientists

Laura Ost, Consulting Editor, Washington, D.C.

George Parsons, Associate Professor, The Graduate College of Marine Studies, University of Delaware

Hugh Phillips, GIS Analyst, Spatial Data Institute

Richard Roth, Jr., Actuary

Richard Roth, Sr., Actuary

Bill Seitz, Professor, Texas A&M University at Galveston

Russell Watkins, Director of Research and Development, Spatial Data Institute

Anthony Yezer, Professor of Economics, The George Washington University

FEDERAL EMERGENCY MANAGEMENT AGENCY PROJECT STAFF

Michael Buckley, Director, Technical Services Division, Mitigation Directorate

Mark Crowell, Project Officer

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Bruce Douglas, University of Maryland, College Park, MD
Carl Frontin, Federal Emergency Management Agency, Washington, D.C.
Robert Hallermeier, Dewberry and Davis, Fairfax, VA
Darryl Hatheway, Dewberry and Davis, Fairfax, VA
Thomas Hayes, Computer Sciences Corporation, Lanham, MD
Sue Hoegberg, Dewberry and Davis, Fairfax, VA
Christopher P. Jones, P.E., Charlottesville, VA
Kerry Kehoe, Coastal States Organization, Washington, DC
Howard Leikin, Federal Insurance Administration, Washington, DC
Ray Matheu, Atlantic/Smith, Cropper & Deeley, LLC, Willards, MD
Mark Mauriello, American Society of Flood Plain Managers
Kathy Miller, FEMA Map Service Center, Jessup, Maryland
Mary-Jean Pajak, Federal Emergency Management Agency, Washington, DC
Ed Pasterick, Federal Emergency Management Agency, Washington, DC
Jeanine DiStefano Petterson, Natural Hazards Center, Boulder, CO
Mike Robinson, Federal Emergency Management Agency, Washington, DC
Spencer Rogers, North Carolina State University Sea Grant, Wilmington, NC
Lynn Russell, Dewberry and Davis, Fairfax, VA
Jerry Sparks, Dewberry and Davis, Fairfax, VA
James Walke, Federal Emergency Management Agency, Washington, D.C.
Paul Wilson, Federal Emergency Management Agency, Atlanta, GA

FOREWORD

Mandated by Section 577 of the National Flood Insurance Reform Act of 1994 (Public Law 103-325), this independent report, *Evaluation of Erosion Hazards*, provides a much-needed and valuable assessment of coastal erosion and the resulting loss of property along our Nation's ocean and Great Lakes shorelines.

I commend the H. John Heinz III Center for Science, Economics and the Environment for its work and for delivering a thought-provoking set of findings, recommendations and policy options. The Center's multi-sector, nonpartisan approach drew experts from around the country to produce, as the Congress envisioned, an objective, science-based report.

One of the report's most sobering findings is that within the next 60 years approximately 25 percent of homes located within 500 feet of the coast (excluding those located in most urban centers) will fall victim to the effects of erosion. Erosion-induced losses to property owners during this time are expected to be half a billion dollars annually, an amount nearly equal to the risk of loss from coastal flooding. If coastal development continues unabated or if sea levels rise as some scientists are predicting, damages may be even higher.

Continued coastal erosion has made both coastal structures and ecosystems vulnerable to storms. An increase in the number and intensity of hurricanes making landfall along some of our most erosion-prone coastlines could dramatically affect those areas. Unfortunately, such an increase in storm activity is precisely what many leading experts are predicting over the next 20 years.

This report clearly lays out the hard choices facing the Congress and the Nation. It is now time – indeed it is past time – to renew the public dialogue about how we can lower the risks to life and property and reduce the costs to the Nation from the inevitable consequences of coastal erosion.

JAMES LEE WITT
Director, The Federal Emergency Management Agency

PREFACE

Coastal erosion and its impact on the National Flood Insurance Program (NFIP) as well as the economic viability and environmental integrity of coastal communities is a major concern of the nation. Homes along our Nation's ocean and Great Lakes shorelines face a risk from erosion comparable to the risk from coastal flooding. However, the NFIP does not currently map erosion hazard areas and therefore is unable to inform homeowners of the risk to their property from erosion. Moreover, FEMA's flood insurance rate maps do not inform current and prospective property owners of erosion risks. In addition, current insurance rates do not reflect the magnitude of the erosion risk. Other NFIP policyholders or taxpayers will have to subsidize what is likely to become a substantial cost.

The Heinz Center conducted an analysis of possible changes to the National Flood Insurance Program (NFIP) based on a national-scale coastal erosion mapping survey for the Federal Emergency Management Agency. The report presents a range of policy options for eroding areas, evaluates the effectiveness of each option in reducing erosion losses, and makes two recommendations.

The report was overseen by a Steering Committee of sixteen experts from academia, government and the private sector which I chaired. The committee and I commend The Heinz Center and its collaborators for their excellent work on a very complex issue. The research was conducted by teams at the University of Georgia (Warren Kriesel and colleagues), the George Washington University (Joe Cordes and Tony Yezer), The Spatial Data Institute (Bill Fry and colleagues), a team of actuaries (Dick Roth Sr. and Dick Roth Jr.), the John F. Kennedy School of Government, Harvard University (Susanne Moser), and the staff of The Heinz Center. Many other individuals at FEMA, especially Mark Crowell, the project officer for this study, and State Coastal Zone Management Agencies generously contributed time and expertise as well.

The committee believes that this report achieves its goal of providing Congress with a series of options from which they can choose to address the problem of coastal erosion. It is our hope that these recommendations and policy options will help set a new course for coastal erosion management.

STEPHEN P. LEATHERMAN
Chair, Erosion Hazards Steering Committee

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SUMMARY

Driven by a rising sea level, large storms, flooding, and powerful ocean waves, erosion wears away the beaches and bluffs along the U.S. ocean and Great Lakes shorelines. Erosion undermines waterfront houses, businesses, and public facilities, eventually rendering them uninhabitable or unusable. By moving the shoreline inland, erosion also brings nearby structures ever closer to the water, often putting them at greater risk than either their owners or insurers recognize.

Over the next 60 years, erosion may claim one out of four houses within 500 feet of the U.S. shoreline. To the homeowners living within this narrow strip, the risk posed by erosion is comparable to the risk from flooding, especially in beach areas. The National Flood Insurance Program (NFIP), however, does not map erosion hazard areas to inform homeowners of the risk they face, nor does it directly incorporate erosion risks into its insurance ratemaking procedures. Both of these shortcomings can be remedied.

BOX S.1 Recommendations

Congress should instruct the Federal Emergency Management Agency to develop erosion hazard maps that display the location and extent of coastal areas subject to erosion. The erosion maps should be made widely available in both print and electronic formats.

Flood insurance rate maps do not inform current and prospective coastal property owners of erosion risks. Without such information, state and local decision makers and the general public are not fully aware of the coastal hazards they face, nor do they have this information available for land-use planning and erosion hazard mitigation. This expenditure is likely to be cost effective.

Congress should require the Federal Emergency Management Agency to include the cost of expected erosion losses when setting flood insurance rates along the coast.

Despite facing higher risk, homeowners in erosion-prone areas currently are paying the same amount for flood insurance as are policyholders in non-eroding areas. FEMA should incorporate the risk from erosion into the cost of insurance along the coasts. Otherwise, other NFIP policyholders or taxpayers will have to subsidize what is likely to become a substantial cost. Using maps such as those recommended above, rate increases could be confined to the highest-risk eroding regions. Alternatively, more modest rate increases could be spread across a larger “Coastal High Hazard Zone” that includes both the highest-risk flood and eroding regions.

Congress debated erosion management legislation during the early 1990s, but could not reach agreement on a course of action. Deciding that more information was needed, Congress passed Section 577 of the National Flood Insurance Reform Act of 1994 (P.L. 103-325), which requested an analysis of a series of possible policy changes to address erosion hazards within federal programs.

This report, by The H. John Heinz III Center for Science, Economics and the Environment, is a response to that mandate. The goal of the study is to improve understanding of the impacts of erosion and erosion-related flooding on the NFIP, other federal programs, and coastal communities. The report makes two recommendations, shown in Box S.1. The report also analyzes the economic impacts of erosion, presents a range of policy options, and evaluates the effectiveness of each option in reducing erosion losses. The key study findings are summarized in Box S.2. The policy options evaluated are listed in Box S.3.

The study was conducted in three phases. In phase 1, the Federal Emergency Management Agency contracted with state agencies to produce maps for 27 counties along U.S. coastlines. The maps included projections of how far inland the coastline may erode over the next 60 years and, where applicable, expected flood heights from a 1 percent chance ("100-year") storm today and in the future. A sample erosion hazard map is shown in Figure S.1. The Heinz Center conducted phases 2 and 3, which included a field survey of over 10,000 structures and analyses of the extent of erosion-related damage and options to address that damage.

This summary describes the nature of the coastal erosion hazard by region, the costs of erosion today and in the future, current federal and state policies in eroding areas, and a series of possible changes to the NFIP to better incorporate coastal erosion into the existing flood insurance program. The recommendations are discussed in greater detail at the conclusion of this summary.

FIGURE S.1 Sample 60-year erosion hazard map, South Bethany, Delaware

Notes: As shown on this aerial photo of South Bethany, Delaware, the beach is expected to erode inland 65 feet (from the white line on the right to the one on the left) over the next 60 years. Two to three rows of houses, marked with circles, are likely to be lost to erosion over this period.

BOX S.2 Summary of Key Study Findings

- Within the first few hundred feet bordering the Nation's coasts, property owners face as large a risk of damage from erosion as they do from flooding. Information about the magnitude of this risk, which varies widely, is generally not available.
- Roughly 1,500 homes and the land on which they are built will be lost to erosion each year, on average, for the next several decades. Costs to coastal property owners will average $530 million per year. Additional beach nourishment or structural protection might lead to lower losses; additional development in the most erosion prone areas will lead to higher losses.
- At current enrollment levels, the National Flood Insurance Program will pay $80 million per year for erosion-related damage, about 5 percent of today's premiums. Total losses will rise with hoped-for enrollment increases.
- Today's property values within the areas most susceptible to coastal erosion have been lowered by a total of $3.3 billion to $4.8 billion nationwide as a result of erosion, a loss of about 10 percent.
- Most of the damage from erosion over the next 60 years will occur in low-lying areas also subject to the highest risk of flooding. Some additional damage will also occur along eroding coastal bluffs.
- Although certain types of erosion damage are not eligible under National Flood Insurance Program rules, most erosion-related losses sustained by policyholders is reimbursed by the program. However, erosion damage is not fully reflected in flood insurance rates; current rates are primarily based on flood risk alone. Thus erosion losses will be subsidized by policyholders in non-eroding areas or by general taxpayers.
- To fully reflect risk, insurance rates in the highest risk coastal areas must be, on average, twice today's rates. Rate increases could be spread uniformly across the highest risk coastal areas or varied according to the risk of erosion-related damage. The rate increases needed to cover expected erosion losses can be designed to be acceptable to a majority of current policyholders, based on results of a mail survey.
- The cost of identifying, mapping, disseminating, and maintaining information on the erosion hazard nationwide is about $5 million per year. For comparison, if all currently empty lots in areas most susceptible to erosion are built on, damage from erosion would rise by roughly $100 million per year for the value of the structures alone. The cost effectiveness of mapping depends on how much the maps reduce development (and rebuilding) within eroding areas, but the investment is likely to be worthwhile.
- Development density in several of the high-risk coastal areas studied by The Heinz Center increased by more than 60 percent over the last 20 years. Roughly 15 percent of this increase appears attributable to the influence of the National Flood Insurance Program. However, the building standards and floodplain management requirements that are part of the program have reduced flood and erosion damage per structure by roughly 35 percent. Thus, for development after 1980, the program has lowered damage by about 25 percent below the level that would have occurred without the program.

BOX S.3 Policy Options Evaluated

The following nine options were evaluated. Options 1–5 are mutually exclusive; that is, only one can be chosen. Any of options 6–9 could be added to any of the other policy packages. Options 2–7 depend on the availability of detailed erosion hazard maps.

1. Maintain the status quo (i.e., no change in policy)
2. Erosion mapping and dissemination alone
3. Creation of a coastal high hazard zone, including both high flood and erosion zones
4. Mandatory erosion surcharge on flood insurance in erosion zones
5. Erosion surcharge combined with regulatory measures to reduce damages
6. Flood-related regulatory changes in erosion zones
7. Erosion insurance in bluff areas susceptible to erosion but not flooding
8. Relocation assistance and/or land acquisition
9. Shoreline protection measures (i.e., nourishment, dune restoration, and structural measures)

THE COASTAL EROSION HAZARD

The erosion hazard was dramatized recently by the predicament of the Cape Hatteras lighthouse in North Carolina. When constructed in 1870, the lighthouse was 1,500 feet from the shore. Protective measures to reduce the rate of beach erosion in front of the lighthouse provided a temporary solution, but, by late 1987, the lighthouse stood only 160 feet from the sea and was in danger of collapsing. In 1999, after several years of debate and lawsuits aimed at blocking a relocation, the National Park Service successfully moved the lighthouse back 2,900 feet at a cost of $9.8 million (see Figure S.2).

Approximately 350,000 structures are located within 500 feet of the 10,000-mile open ocean and Great Lakes shorelines of the lower 48 states and Hawaii. This estimate does not include structures in the densest areas of large coastal cities, such as New York, Chicago, Los Angeles, and Miami, which are heavily protected against erosion.

Of these, about 87,000 homes are located on low-lying land or bluffs likely to erode into the ocean or Great Lakes over the next 60 years. The breakdown by region is shown in Table S.1. Assuming no additional beach nourishment or structural protection, roughly 1,500 homes and the land on which they are built will be lost to erosion each year. An example of a house threatened by erosion is shown in Figure S.3.

Within the highest risk flood hazard areas (“V-zones”) of the Atlantic and Gulf of Mexico coasts, the risk of damage from erosion is almost equal to, and added to, that from flooding. Much of the Pacific and Great Lakes shorelines are backed by steep cliffs or bluffs susceptible to erosion also.

FIGURE S.2 In 1999 the National Park Service moved the Cape Hatteras lighthouse back 2,900 feet to a more stable position.

(Photo by Drew Wilson, The Virginia Pilot)

TABLE S.1 Nationwide Estimate of Structures Susceptible to Erosion[a]

Variable	Atlantic Coast	Gulf of Mexico	Pacific Coast	Great Lakes	Total
Length of coastline					
Miles	2,300	2,000	1,600	3,600	9,500
Percentage of total	24%	21%	17%	38%	
Structures within 500 feet of shoreline					
Number	170,000	44,000	66,000	58,000	338,000
Percentage of total	50%	13%	20%	17%	
Structures within 60-year erosion hazard area (EHA)[b]					
Number	53,000	13,000	4,600	16,000	87,000
EHA structures as % of those within 500 feet of shoreline	31%	29%	7%	28%	
Structures within 60-year EHA assuming all open lots are filled					
Number	76,000	22,000	5,200	>16,000[c]	>120,000

[a] All estimates exclude structures in major urban areas. The analysis assumes these structures will be protected from the erosion hazard.
[b] The 60-year EHA is determined by multiplying local erosion rates by 60 years.
[c] Data on open lots not available in Great Lakes
Data may not add to totals because of rounding.

FIGURE S.3 As a result of erosion, this oceanfront house is now on the beach.

(Photo by The Heinz Center)

The average annual erosion rate on the Atlantic coast is roughly 2 to 3 feet/year. States bordering the Gulf of Mexico have the nation's highest average annual erosion rates (6 feet/year). The rates vary greatly from location to location and year to year. A major storm can erode the coast inland 100 feet or more in a day. The coastline often accretes partway back over the next decade. Both the Atlantic and Gulf coasts are bordered by a chain of roughly 300 barrier islands, which are composed primarily of loose sand and are the most dynamic land masses along the open-ocean coast. Barrier island coastlines have been retreating landward for thousands of years in response to slowly rising sea levels.

The Pacific coastline consists of narrow beaches backed by steep sea cliffs that are composed of crumbly sedimentary bedrock and are therefore unstable. In addition, the cliffs are heavily faulted and cracked, and the resulting breaks and joints are undermined easily by wave action. Cliff erosion is site specific and episodic. In some locations, the cliffs can retreat tens of feet at one time, whereas 50 to 100 feet away, there is no retreat at all. As a result, long-term average annual erosion rates are usually less than 1 foot/year, but these low averages hide the true nature of large, episodic events. Similarly, along the shores of the Great Lakes, rates of bluff and dune erosion vary from near zero to tens of feet per year because of annual variability in wave climate and lake levels.

COSTS OF EROSION TODAY AND IN THE FUTURE

Property Losses and Insurance Payouts

Nationwide, erosion may be responsible for approximately $500 million in property loss to coastal property owners per year, including both damage to structures and loss of land. The breakdown by region is shown in Table S.2.

These conclusions are based on detailed field measurements and mail survey information collected on approximately 3 percent of the buildings located within 500 feet of the shore. The Heinz Center sent field survey teams to measure and photograph 11,450 structures in 18 counties. Additional information on these same structures was obtained from county assessor and similar offices, and detailed questionnaires mailed to the owners. Researchers intensively studied 120 miles of shoreline, or about 1 percent of the U.S. coastline outside of Alaska and Hawaii. The areas studied are shown in Figure S.4 along with their typical erosion rates.

Not all of the $500 million in annual property loss will be covered by the NFIP, however. First, insurance does not cover loss of land. In addition, the NFIP limits coverage to $250,000 and many coastal houses are worth considerably more. Finally, results of The Heinz Center's mail survey indicate that roughly half the homeowners in high erosion areas on the Atlantic and Gulf coasts currently purchase flood insurance, which to large extent covers erosion losses, as well. On the Pacific and Great Lakes coasts, where bluff erosion is a problem, 10 percent or fewer of at-risk houses are insured. Assuming that NFIP enrollment remains at present rates, the payout over the next few decades for erosion losses is likely to be roughly $80 million per year.

The breakdown by region is shown in Table S.2. Table S.3 compares estimates of erosion along the Atlantic coast today to the higher losses projected decades into the future. Note that NFIP payments in erosion-prone areas over the last decade were *lower* than the losses projected in Tables II and III. Averaged over the last decade, premiums paid by owners of houses built after 1981 have been sufficient to cover losses, as required by law. However, as the shore erodes inland, damage to these structures will rise.

FIGURE S.4 Average Annual Erosion Rates (feet/year) within Counties studied in The Heinz Center's Evaluation of Erosion Hazards

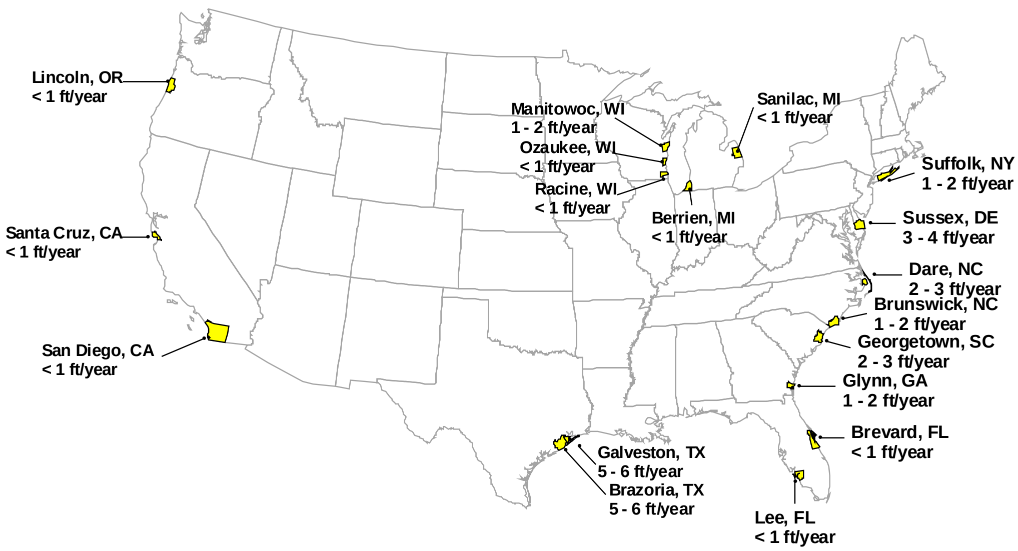


TABLE S.2 Nationwide Estimates of Cost of Erosion: Average Annual Losses to Current Properties Within 60 Year EHA (in Millions of Dollars per Year)

Affected Entity	Atlantic Coast	Gulf of Mexico	Pacific Coast	Great Lakes	Total
Owners[a]					
	$320	$50	$110	$50	$530
Community[b]					
	$260	$50	$70	$30	$410
National Flood Insurance Fund[c], assuming 100% enrollment:					
	$130	$20	$10	$30	$200
National Flood Insurance Fund[c], assuming current enrollment					
	$70	$10	$1	$2	$80

[a] Loss of structure and land.

[b] Loss of structure and land, not including the "amenity value" of the oceanfront, which is transferred from owner to owner.

[c] Payments from the National Flood Insurance Fund are for damage to structures and contents only.

Data may not add to totals because of rounding.

TABLE S.3 Estimates of Cost of Erosion Along the Atlantic Coast: Variation in Average Annual Losses Through Time (in Millions of Dollars per Year)

Affected Entity	Within 30 Year EHA	30 to 60 Years from Today (Existing Structures Only)	30 to 60 Years from Today (Assuming All Lots Filled)[a]
Owners[b]			
	$200	$440	$630
Community[c]			
	$160	$360	$510
National Flood Insurance Fund[d], assuming 100% enrollment			
	$80	$180	$260
National Flood Insurance Fund[d], assuming current enrollment			
	$40	$90	$130

[a] Vacant lots are, on average, about 30 percent of total lots.
[b] Loss of structure and land.
[c] Loss of structure and land, not including the "amenity value" of the oceanfront, which is transferred from owner to owner.
[d] Payments from the National Flood Insurance Fund are for damage to structures and contents only.
Data may not add to totals because of rounding.

Property losses are just one of the many costs of shore erosion. A recent study by The Heinz Center (1999), *The Hidden Costs of Coastal Hazards*, emphasizes that many hidden or unreported costs related to coastal hazards are imposed on the business community, individuals, families and neighborhoods, public and private institutions, and natural resources and the environment. Although that study focused on weather-related coastal hazards, such as hurricanes and other severe storms, erosion clearly influences the stability and condition of coastal property and beaches when such disasters strike a community.

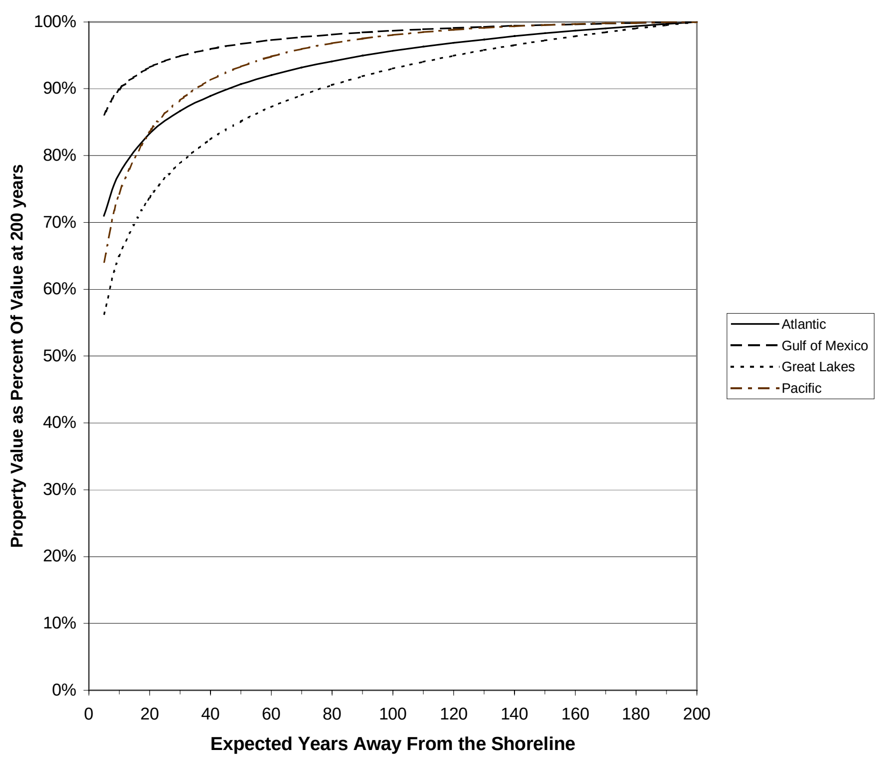
Reduced Property Values

Research conducted by The Center's collaborators at The University of Georgia shows a strong relationship between house price and the number of years until the nearest shoreline is likely to erode and reach the house (determined by dividing the distance from the shore by the erosion rate). Houses close to a rapidly eroding shore are worth less today than otherwise identical houses that are close to shorelines that are relatively stable. The increased risk of damage is reflected in sales price. This relationship for typical waterfront properties – at the same distance from the water today, but with shores eroding at different rates – is shown in Figure S.5.

Along the Atlantic coast, a house that is 50 years from the shoreline is estimated to be worth about 90 percent of an identical house located 200 years from the shore; likewise, a house estimated to be within 10 to 20 years of an eroding shore is worth 80 percent of one located 200 years away. This varies somewhat from region to region, but the Atlantic coast results are typical.

By adding up these estimates across the 53,000 structures currently inside the 60-year erosion hazard area on the Atlantic Coast, The Heinz Center estimates a depression in today's property values to the owners of these homes of approximately $1.7 to 2.7 billion. (The 60-year erosion hazard area is the land expected to be lost to erosion over the next 60 years.) The estimated depression in property values for the 87,000 houses within the 60-year erosion hazard area nationwide is $3.3 to 4.8 billion. If houses are built on all the remaining empty lots within the 60-year erosion hazard area, then the loss in property value might total $4.6 to 6.6 billion. The breakdown by region is shown in Table S.4.

FIGURE S.5 Effect of erosion hazard on typical coastal property value[a]



[a] Property value for otherwise identical waterfront houses, at the same distance from the water today, but with shores eroding at different rates.

TABLE S.4 Estimated Economic Impacts of Erosion in 60-Year Erosion Hazard Areas Nationwide (in Millions of Dollars)

	Atlantic Coast	Gulf Coast	Great Lakes	Pacific Coast	Total
Loss in property value	$1,700–$2,700	$100–$200	$600–$900	$900–$1,000	$3,300–$4,800
Loss in property value, assuming all empty lots are filled	$2,500–$3,800	$200–$300	$900–1,300[a]	$1000–$1,200	$4,600–$6,600

[a] Percentage of empty lots extrapolated from average of other regions.
The loss in property value represents depression in property price prior to any damage.
Data may not add to totals because of rounding.

CURRENT POLICIES IN ERODING AREAS

Currently, erosion is addressed in a piecemeal manner by Federal, state, and local governments as well as private owners. These activities are summarized in Table S.5. Federal activities and programs include: the NFIP, which reimburses its policyholders for erosion losses; coastal engineering projects, such as beach nourishment, that help protect against erosion; funding and technical assistance to states; and purchase of coastal areas for public ownership. The Coastal Barrier Resources Act restricts federal expenditures, including flood insurance and disaster assistance, within designated Coastal Barrier Resources System Units. The system encompasses nearly 1.3 million acres and approximately 1,200 miles of shoreline.

TABLE S.5 Summary of Approaches to Erosion Management by Level of Response

Level of Response	Approaches to erosion management
Individuals	• Protect private property through structural and non-structural measures • Comply with building codes and land use regulations
Communities, Local governments	• Establish and enforce building codes and land use regulations • Enforce NFIP building and floodplain management requirements • Participate in federal and non-federal shore protection projects
States	• Establish and enforce setback policies • Regulate the use of shoreline stabilization structures • Require disclosure of erosion hazards in real estate transactions • Participate in federal and non-federal shore protection projects
Federal agencies	• Provide flood insurance coverage (FEMA – NFIP) • Prohibit federal expenditures in designated coastal barriers (U.S. FWS – Coastal Barrier Resources Act) • Provide disaster response and recovery assistance (FEMA) • Support state erosion management programs (NOAA – CZMA) • Participate in federal shore protection projects (U.S. ACE)

Key:
CBRA Coastal Barrier Resources Act
CZMA Coastal Zone Management Act
FEMA Federal Emergency Management Agency
NFIP National Flood Insurance Program
NOAA National Oceanic and Atmospheric Administration
U.S. ACE U.S. Army Corps of Engineers
U.S. FWS U.S. Fish and Wildlife Service

Coastal Erosion and The National Flood Insurance Program

The National Flood Insurance Program was established in 1968 "to provide flood insurance in communities which adopt and adequately enforce floodplain management ordinances that meet minimum [program] requirements" (National Flood Insurance Act of 1968, P.L. 90-448).

The program has three objectives:

- Identify flood risks and disseminate this information to the public, lenders, insurance and real estate agents, and state and local governments;
- assure the purchase of sufficient insurance and the enrollment of adequate numbers of communities and individuals to curtail the expansion of federal disaster relief and flood control programs; and

- encourage wise use of the floodplain through mitigation requirements and activities in communities that wish to obtain federally backed flood insurance.

Erosion is not well addressed by the current NFIP. Although certain types of erosion-related damage are not reimbursable under program rules, the NFIP appears to pay for most erosion-related damage claims in low-lying areas. A survey of insurance agents by The Heinz Center found no case where policy holders failed to submit a claim, or the program denied a claim, because of erosion. However, current insurance rates do not reflect the magnitude of the erosion risk faced by any individual policyholder. Thus, future claims by homeowners in erosion-prone areas will have to be subsidized by others. Moreover, because current flood maps do not incorporate erosion risk, they are not only incomplete but also misleading to users. The next section presents a comprehensive series of policy options to remedy these shortcomings. The Heinz Center's recommendations are presented at the conclusion of this summary.

POLICY OPTIONS

Nine policy options, or packages of options, were developed and analyzed. Options 1–5 are meant to be mutually exclusive; that is, only one can be chosen. These are ordered roughly from least to most extensive policy intervention. Any of options 6–9 could be added to any of the other policy packages. Options 2–7 depend on the availability of detailed erosion hazard maps. Each option is summarized and evaluated below.

To help sort through the nine options, The Heinz Center constructed a series of evaluation criteria that reflect possible goals for changes to the flood program. The criteria are as follows:

- Will the public be better informed about the risks of living on the coast?

- Does the change help alleviate economic hardships from erosion damages that do occur?

- Is the program fairer?
  - Will insurance rates more closely reflect risk?
  - Are additional restrictions imposed on property owners?

- Does the change lead to reduced damage to structures?
  - Does it avert damage to structures not yet built?
  - Does it help reduce damage to existing structures?

- Does the change lead to other desirable outcomes, such as environmental benefits or enhanced opportunities for recreation?

- Is the change cost effective for affected individuals?

Option 1. Maintain the Status Quo

Nineteen of 30 coastal states currently incorporate erosion risks into the approval process for new construction close to the shoreline. The erosion management activities undertaken by states and communities are summarized in Box S.4. However, information about erosion risks is spotty, and both the information and its usage are inconsistent from state to state. Although the NFIP appears to reimburse most erosion-related damage in low-lying areas, current insurance rates do not reflect the variation in risk among policyholders. Thus, claims by homeowners in erosion-prone areas will have to be subsidized by policyholders in non-eroding areas. The regulatory components of the NFIP have reduced damage from flooding but are less successful with respect to erosion.

Option 2. Erosion Mapping and Dissemination Alone

The preparation of maps displaying the location and extent of areas subject to erosion would be the simplest and least intrusive change to the NFIP. The maps, if made widely available, would help to better inform the public about the risks of living along the coast. Erosion mapping is also a requisite component of options 3 through 7. FEMA estimates that a nationwide erosion hazard mapping program would cost $44 million. Assuming that a map is useful for 10 years, annual costs would be roughly $5 million per year. Depending on the region, if such maps discourage more than 2 to 7 percent of development on currently empty lots within the 60-year erosion hazard area, the investment will be worthwhile.

Erosion is a highly variable process, thus the maps would reflect only a statistical "best guess" of how much the shore might erode over the next several decades. Furthermore, the maps would be based on data from historical maps and aerial photographs—data that can be sparse and difficult to interpret. Nevertheless, such information is extremely helpful to many types of users of flood insurance rate maps.

BOX S.4 Present Status of Erosion Management at the State and Community Levels

Thirty states and five territories border the U.S. coastline. States have adopted land-use plans, regulations, building standards, and other programs for addressing coastal storms, floods, and erosion. Particularly since the passage of the 1972 Coastal Zone Management Act (P.L. 92-583), coastal states have been central players in the management of coastal resources and shorefront areas.

State-level responses to erosion range from doing nothing to restricting the use of hard structures and enforcing erosion-rate based setbacks (e.g., North Carolina), to providing loans to stabilize the shoreline through cliff-hardening (e.g., the Maryland Chesapeake Bay). Nineteen of 30 coastal states currently incorporate erosion risks into the approval process for new construction close to the shoreline. However, information about erosion risks is spotty, and both the information and how it is used is inconsistent from region to region.

Generally, states have delegated their land-use authorities to local governments. Therefore, the National Flood Insurance Program requires each community to adopt floodplain management requirements, including performance standards for new construction and substantial improvements to existing buildings located in special flood hazard areas on the Flood Insurance Rate Maps.

Communities or local governments address coastal erosion problems by developing and enforcing local ordinances to guide decisions on land use, zoning, subdivision practices, building standards, hazard mitigation, and management of public beach areas. Through the Community Rating System (a flood insurance rating and community inspection program), policyholders receive reductions in their premiums if the community implements floodplain management activities that exceed the National Flood Insurance Program's minimum requirements.

As part of this study, The Heinz Center conducted case studies of community responses to coastal erosion (Chapter 4 and Appendix F). These examples show how communities may react to policy changes at the federal level and how their concerns might be addressed.

Option 3. Creation of a Coastal High Hazard Zone, including both High Flood and Erosion Risks

FEMA could establish a single "coastal high hazard zone" encompassing the current highest-risk flood zone (the “V-zone”) and any additional areas highly susceptible to erosion. Insurance rates would increase to reflect both risks. On the Atlantic and Gulf coasts, the combined region would be roughly 15 percent larger than the current high-hazard V-zone.

If Congress directs FEMA to increase insurance rates to fully cover expected erosion damage, rates in the new area would rise a fixed amount between $.90 and $1.00/year per $100 of coverage. This is in addition to current rates that vary by flood risk. Under this option, all policyholders share the costs of erosion damage equally.

One advantage of this option is that it contains the cost of erosion to within the coastal high hazard zone, thus eliminating future subsidies from other NFIP policyholders (such as inland homeowners). Because it also requires erosion hazard mapping (discussed in option 2), the public will be better informed about the risks of living along the coast.

The main disadvantage of this option is that it does not bring insurance rates fully into line with the risk faced by individual homeowners within the coastal high hazard zone. Thus, policyholders in low erosion areas will still be subsidizing those located within more erosion-prone ones.

Option 4. Mandatory Erosion Surcharge on Flood Insurance in Erosion Zones

Many homeowners pay insurance rates far lower than is necessary to cover the risks caused by both flooding and erosion. Thus, either other NFIP policyholders or taxpayers will subsidize future erosion damages. Congress could direct FEMA to impose an erosion surcharge on current flood policies in erosion-prone areas to cover the additional risks and thus reduce the subsidy. The surcharge would have to be mandatory because the flood program already pays for most losses from erosion (in low-lying areas), and few policyholders would be likely to pay extra for erosion coverage that they get free of charge today. Moreover, it is not practical to distinguish between damage from flooding alone and that from erosion-related flooding.

This option would help bring insurance rates closer in line with expected damage and like the previous two options, would help better inform the public about the risks of living along the coast. Fairness is one of the most compelling reasons in favor of a mandatory erosion surcharge.

Option 5. Erosion Surcharge Combined with Regulatory Measures to Reduce Damages

Under the NFIP, flood insurance is offered to individuals on the condition that the community adopts regulations to reduce future damage. Following this model, other measures—such as setback requirements or building code changes—could be required in erosion-prone areas as a condition of allowing residents to remain eligible for combined flood and erosion insurance. NFIP elevation and related floodproofing requirements have been effective at reducing flood damage (see Box S.5) but are not as effective for reducing erosion damage.

Mandatory setbacks determine how close to the shoreline structures can be built or rebuilt. FEMA could follow one or more of the approaches taken by state coastal zone management programs in establishing setbacks. Nineteen of 30 coastal states have setbacks or land use controls in place along the coast (see Box S.4). Seven states established setback distances based on expected years from the shoreline. Typical setbacks are 30 years for houses and 60 years for larger structures. The remainder specify a fixed setback distance in feet from the shoreline, typically between 25 feet to 100 feet. Alternatively, the two approaches may be combined (i.e., no development within 50 feet or within the 30-year EHA) to provide an additional safety margin.

FEMA could also require communities to adopt building code changes to reduce the impacts of erosion-related damages. For example, structures could be designed so that they could be moved and relocated more easily in the event that an eroding shore gets too close. Removal of a structure that ends up within, for instance, the 10-year erosion line could be required.

A key issue associated with this option is whether Congress decides that the public benefits of setback requirements or mandatory removal of structures outweigh the potential hardship from imposing restrictions on how individuals may use their land. Congress could follow a different path if there is hesitancy to assign additional regulatory responsibilities to states and localities. It might simply choose to deny insurance—for both flooding and erosion—to new structures in the highest-risk erosion zones. Building in these areas would not be prohibited, but the owners of new structures would not be eligible for federal flood insurance or disaster assistance grants or loans. This is similar to the approach followed in the Coastal Barrier Resources Act.

Option 6. Flood-related Regulatory Changes in Erosion Zones

Erosion not only causes damage directly, but also, over time, increases the risk from flooding. The likelihood of damage could be lowered somewhat if communities were directed to apply building standards appropriate to the flood conditions expected several decades from now. Newly constructed houses, or houses rebuilt after substantial damage, that are located in flood zones also susceptible to erosion, could be required to meet building standards with an added margin of safety based on the anticipated erosion of the coast.

Building in some additional flood resistance is cheaper during the design and building phases than it is after a structure has been built. However, we were not able to ascertain how large a margin of safety would be cost effective.

Option 7. Erosion Insurance in Bluff Areas Susceptible to Erosion but not Flooding

Although many houses on bluffs overlooking the coast are subject to erosion damage, homeowners in these areas typically have not purchased flood insurance. Only 10 percent or fewer of the susceptible structures in the bluff areas of the Great Lakes and Pacific coasts are covered, even though annual erosion damages in these areas may exceed $100 million per year. Coverage may be low in bluff areas because the National Flood Insurance Act limits coverage of erosion damage to that "caused by waves or currents of waters exceeding anticipated cyclical levels." Hence, there may be a greater likelihood of a claim being rejected in bluff areas than in low-lying areas. Insurance specifically covering erosion risks in bluff areas would be more consistent with the actual problems in these areas.

Any extension of erosion insurance into bluff areas would need to be pursued with caution, to make sure it did not encourage development in eroding areas. The NFIP appears to have contributed modestly to the increase in low-lying coastal areas, but because of the success of building standards, overall flood damage is lower than it would have been without the program (see Box S.5). Building standard changes are not likely to be as effective for lowering erosion damage, thus the overall effect of extending insurance to bluffs is unclear. Nevertheless, this option would serve to reduce the hardship if and when damage does occur.

BOX S.5 Effects of Erosion Risk, Flood Risk, and Flood Insurance on Development

The Heinz Center study evaluated some of the effects of the National Flood Insurance Program, which has never been fully assessed. A team of researchers at The George Washington University reconstructed 35-year development histories of 120 blocks of homes within seven of the counties inventoried. Four of the counties were on the Atlantic coast, two were on the Gulf of Mexico, and one on the Pacific coast.

Within these counties, development density more than doubled over the 35 years. With such overall growth as background, the researchers used statistical regression methods to examine whether the amount of land developed in each block was related to the risk of erosion; the risk of flooding; as well as other factors, such as whether it was a waterfront block. The research team also explored whether the availability of flood insurance affected the density of development.

Just as erosion affects property prices, so, too, does it affect the density of development. For blocks within the front (ocean-side) half of the 60-year erosion hazard area, the closer the block was to the ocean in years, the lower the development density. Outside the 60-year erosion hazard area, the closer the block was to the ocean in years, the more rapid the development.

The research team also found that flood risk affects the density of development. In the absence of insurance and other programs to reduce flood risk, development density would be about 25 percent lower in the highest-risk zones than in areas less susceptible to damage from coastal flooding. After the adoption of the National Flood Insurance Program, development density was roughly 15 percent lower in areas now classified as highest risk than in other areas. Thus, it appears that although development density is still lower than average in high-risk flood areas, the difference is smaller than it was before the program.

Although development density has increased, flood damage may be lower than it would have been if the National Flood Insurance Program had never been enacted, because of the program's floodplain management and building code requirements. Structures built after the program's building requirements went into effect in 1981 are expected to sustain significantly less damage during floods than are older structures built prior to the program. Overall, the net damage to "post-1981" structures is about 25 percent lower than it would have been if the new development had occurred at the lower densities, but higher rates of damage per structure, that would have occurred without the program.

Option 8. Relocation Assistance and/or Land Acquisition

The Heinz Center estimates that roughly 10,000 structures are within the estimated 10-year erosion zone closest to the shore. A program of relocation assistance and/or land acquisition could encourage removal of these high-risk structures before they are destroyed. Such a program might make the most sense if linked to some of the regulatory options under Option 5, such as revocation of insurance once a structure enters the 10-year erosion zone, unless the structure is relocated. Buyouts, or acquisition of property, already are used by many states and the federal government as a risk-reduction strategy. Under the rules for buyouts funded by the Federal Emergency Management Agency, the land purchased is deeded permanently as open space. Acquisition offers a way to permanently reduce or eliminate susceptibility to flood damage in the highest-risk areas. It also can be used to achieve important community and environmental protection goals, such as public beach access and preservation of open space and wildlife habitat.

This option has not been used extensively because of the high costs of coastal property. Mandatory programs also would provoke objections from private landowners. A previous attempt to encourage removal and relocation of threatened structures—the Upton-Jones Program, which existed from 1987 to 1994–was suspended because of limited usage and unintended outcomes. A relocation program, if pursued, would have to be carefully designed to avoid the shortcomings of the Upton-Jones Program.

Option 9. Shoreline Protection Measures (Nourishment, Dune Restoration, and Structural Measures)

Like relocation, shoreline protection is one of the few options that can reduce damage to existing structures. Interest in shoreline protection measures by current property owners is clear, especially in areas with a high density of existing structures and limited shoreline. Protective measures include beach nourishment, dune restoration, and armoring of the shoreline with hard structures. Individuals, communities, and states already build many such projects. Protection measures such as dune restoration are likely to lead to environmental improvements. However, hard structural measures, such as groins, bulkheads, and rip-rap, can have negative impacts on the physical and aesthetic characteristics of beaches by reducing beach width, disrupting sand supplies, and limiting recreational use of the beach.

The U.S. Army Corps of Engineers spent about $700 million between 1950 and 1993 (in 1993 dollars) on beach nourishment of about 200 miles of coast. Continued maintenance and renourishment costs roughly $300,000/year per mile of coast. However, expected annual erosion damage exceeds nourishment costs in only one of the 10 Atlantic and Gulf coast counties in The Heinz Center sample. Thus, nourishment of additional stretches of the coast, if desired at all, will only pass a benefit-cost test for federal funding in limited, high-density areas. Shoreline protection measures can augment, but are not substitutes for, other options.

RECOMMENDATIONS

Based on the analyses presented in this report, The Heinz Center recommends that Congress take, at minimum, the following two actions. The Heinz Center believes that these two recommendations provide significant benefits, are cost effective, and are acceptable across most of the political spectrum. The other options we presented will lower damage or alleviate economic hardship should damage occur. Congress should consider the advantages and disadvantages of these options within the framework of existing Federal, State, and local programs.

Congress should instruct the Federal Emergency Management Agency to develop erosion hazard maps that display the location and extent of coastal areas subject to erosion. The erosion maps should be made widely available in both print and electronic formats.

Flood insurance rate maps do not inform current and prospective coastal property owners of erosion risks. The omission is substantial. Averaged over the highest hazard flood zone, the risk of erosion-related damage to structures is roughly equal to the risk of flood damage. Thus, the current maps, which show only flood hazards, are misleading.

Without accurate information on erosion, state and local decision makers and the general public will not be fully aware of the coastal hazards they face, nor will they be able to make use of this information for land-use planning and erosion hazard mitigation.

Congress should require the Federal Emergency Management Agency to include the cost of expected erosion losses when setting flood insurance rates along the coast.

Despite facing higher risk, homeowners in erosion-prone areas currently are paying the same amount for flood insurance as are policyholders in non-eroding areas. FEMA should incorporate the additional risk from erosion into the determination of actuarial rates in high-hazard coastal regions. This will eliminate the need for subsidies from other NFIP policyholders or taxpayers to cover expected erosion losses.

Erosion risk can be incorporated in several ways. The simplest is to combine the highest hazard flood zones and erosion hazard areas into a "Coastal High-Hazard Zone." Erosion risk would be shared equally among all policyholders in the new combined zone. Alternatively, FEMA could charge rates based on a refined risk classification that separately distinguishes erosion and flood risks. Only those policyholders in erosion hazard areas (about one-third of the coastal high-hazard zone) would be charged an erosion surcharge.

Discussion of Recommendations

Given the magnitude of the risk posed by coastal erosion and the misleading nature of the current "flood only" coastal hazard maps, FEMA should be directed to prepare maps of erosion risks of at least the quality of current flood maps. Ideally, these maps should display both risks and be made available in both paper and electronic forms.

FEMA estimates such maps, covering 12,500 miles of U.S. ocean and Great Lakes shoreline of greatest concern, would cost approximately $44 million—less than $5 million per year over their expected 10-year useful life. While it is difficult to estimate the effect such information would have on future development decisions, the effect would not have to be large to justify the costs. If the availability of erosion maps lowers future damage by just a few percent, the savings would exceed the costs. Alternative federal erosion-related expenditures are unlikely to be more cost-effective. For example, spending an equivalent amount on beach nourishment would protect roughly another 10 miles of shoreline. And though these funds could be used to further improve existing flood maps, far less information about erosion—a risk about equal to flood in coastal regions—is available.

In addition to the use of erosion maps by individual homeowners and communities, FEMA must have them if they are to include the costs of erosion losses when setting coastal insurance rates. As presented earlier (Table S.2), FEMA's liability for erosion losses is likely to average $80 million per year without any further development in erosion-prone areas. If erosion hazards are not adequately factored into current flood insurance rates, losses will have to be subsidized by other NFIP policyholders or taxpayers. Losses of this level are a small fraction of the total earned premiums collected nationwide (currently about $1.3 billion per year), but within coastal regions, the percentage is substantial.

Table S.6 includes estimates of insurance rate increases from several alternative ways to charge policy holders for the cost of erosion damage. By spreading the costs over a newly created Coastal High Hazard Zone, rates for all policy holders in both High Hazard Flood Zones (V-zones) and the 60-year Erosion Hazard Area will rise roughly $.90/year per $100 of coverage.

TABLE S.6 Insurance Rate Increases[a]

	High Hazard Flood Zone, Not EHA[b]	Erosion Hazard Area	Subsidized Rate
Combined Flood and Erosion Coastal High Hazard Zone	$0.90	$0.90	$0.35
Single Zone Erosion Hazard Area			
0- to 60-year EHA	No increase	$2.45	$0.95
Two Zone Erosion Hazard Area For New Structures			
0- to 20-year EHA	No increase	$11.40	N.A. [c]
20- to 60-year EHA	No increase	$1.75	N.A.

[a] Surcharges are given in dollars per year per $100 of coverage for a 1-4 family residence. Rates for new structures and post-1981 structures are calculated to be revenue neutral within each zone. Assumptions: Federal Insurance Administration (FIA) pays for 85 percent of damage (remainder is wind damage paid for by private insurers); interest rate is 3 percent; FIA overhead is 35 percent; subsidized structures pay 38 percent of post-81 rates.
[b] Erosion hazard area
[c] Not applicable

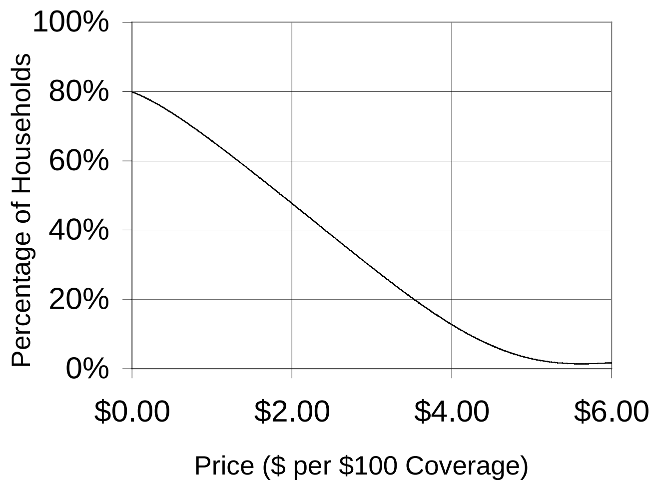
If Congress chooses to extend subsidies to some existing structures (similar to the current flood insurance program, which subsidizes many houses built prior to 1981), those structures would pay increases of about $.35/year per $100 of coverage.

If rate increases are confined to only those structures in the 60-year erosion hazard area, rates would have to rise by roughly $2.45/year per $100 of coverage to fully cover expected losses. Again, if Congress chooses to subsidize some (or all) current policyholders, following the percentages used elsewhere under the program would lead to rate increases of roughly $1.00/year per $100 of coverage.

Congress may prefer to treat future construction differently. Unlike the owners of existing houses, builders of new homes can choose where to locate. Congress can give builders of new homes an incentive to build further back from the shoreline within eroding areas by charging higher rates closer to the shore and lower rates further inland. Rate increases are shown for two zones, 0-20 and 20-60 years. Note that rates in the zone closest to the shoreline would have to rise to $11.40/year per $100 of coverage—over 10 percent of the value of the house each year. Rate increases in the zone set back from the shoreline could then be held to a much more modest rate, $1.75/year per $100 of coverage.

The Heinz Center's mail survey of homeowners found that about half of flood policyholders would be willing to buy optional erosion insurance at a cost less than $1-$2/year per $100 of coverage (see Figure S.6). However, at rates exceeding $5/year per $100 of coverage, voluntary participation would be quite low. Thus, most of the rate increases shown in Table S.6 seem within the range of public acceptability. While the rate increase for new construction closest to the shore may at first appear unreasonably high, to many homeowners it may still be preferable to such alternatives as denial of insurance, or outright bans on construction, for such risky locations. Other options for subdividing the erosion hazard area are described in chapter 6 of the report.

FIGURE S.6 Percentage of households willing to voluntarily purchase erosion policies.



1.

INTRODUCTION

Coastal erosion is a problem affecting the shores and communities of the United States and the environmental integrity of its coasts. Erosion also affects the National Flood Insurance Program (NFIP) and NFIP policyholders by causing damage that leads to claims. A series of Congressional actions, particularly the National Flood Insurance Reform Act (NFIRA) of 1994 (P.L. 103-325), have been aimed at assessing and reducing erosion-related losses. Section 577 of the NFIRA (see Appendix A) mandates that a study be conducted to explore the effects of erosion and erosion mapping on the NFIP, its policyholders, and coastal communities prone to erosion. This report is a response to that mandate.

The policy options and questions contained in Section 577 were presented and debated in previous legislative proposals for establishing erosion zones within the NFIP.[1] The goal of this study by The H. John Heinz III Center for Science, Economics and the Environment is to improve understanding of the impacts of erosion and erosion-related flooding on the NFIP, other federal programs, and coastal communities. Rather than prescribe a specific policy, this report presents a range of policy options and recommendations, and evaluates their economic impact as well as their effectiveness in reducing erosion losses. In particular, the study

- determines the extent of coastal property at risk from erosion and related hazards, particularly flooding;

- estimates the expected damage from flooding and erosion over the next 60 years;

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[1] House bills: H.R. 4461, 1990; H.R. 1236, 1992; H.R. 62, 1993; HR 3191, 1994. Senate bills: S. 1650, 1991; S. 2907, 1992, S. 1405, 1993.

- evaluates the economic effects of policy changes to the NFIP that would require erosion mapping; and

- compares these changes to other possible policy measures or actions.

CONDUCT OF THE STUDY

The *Evaluation of Erosion Hazards* study was conducted in three phases. In phase 1, the Federal Emergency Management Agency (FEMA) contracted with various state agencies to produce 60-year erosion hazard areas (EHAs) in 27 counties. The Heinz Center conducted phases 2 and 3, which included a field survey of structures and an economic analysis of policy changes in EHAs. The Heinz Center also performed case studies of community responses to coastal erosion. Each phase is described briefly below.

Phase 1: Mapping Erosion Hazard Areas

In 1995, FEMA initiated the mapping of 27 counties distributed among 18 coastal and Great Lakes states. The agency allocated funds to state coastal zone management agencies, or their designees, to map the following features:

- 60-year EHAs, calculated by multiplying erosion rates at each site by 60 years;

- current Flood Insurance Rate Map (FIRM)-based flood zones, including V-zone/A-zone[2] boundaries and some A-zone/X-zone boundaries, both with associated base flood elevations (BFEs) and gutter lines (i.e., contour lines within flood elevations that separate areas with different BFEs); and

- 60-year projected FIRM-based flood zones. These zones were determined by projecting the current FIRM-based flood zones landward by approximately the distance that the beach is expected to erode during the next 60 years (i.e., the width of the 60-year EHA).

The methods used and results of the phase I erosion hazard area mapping are described more fully in Appendix B and in Crowell and Leatherman, 1999.

Phase 2: Structure Inventory and Geographic Information System Development

Using the 60-year projected erosion hazard zones, the number of structures in each EHA was approximated for all 27 counties. The Heinz Center's

[2] The various zones, which indicate differing risks of flooding, are defined and discussed in Chapter 3.

subcontractor, Spatial Data Institute, conducted field survey measurements of 11,234 structures in or near 60-year EHAs. Because of cost constraints and the limited availability of assessment data on structures, field surveys were conducted in only 18 of the 27 counties (see Figure 1.1). All geographic regions of the United States were represented in the study.

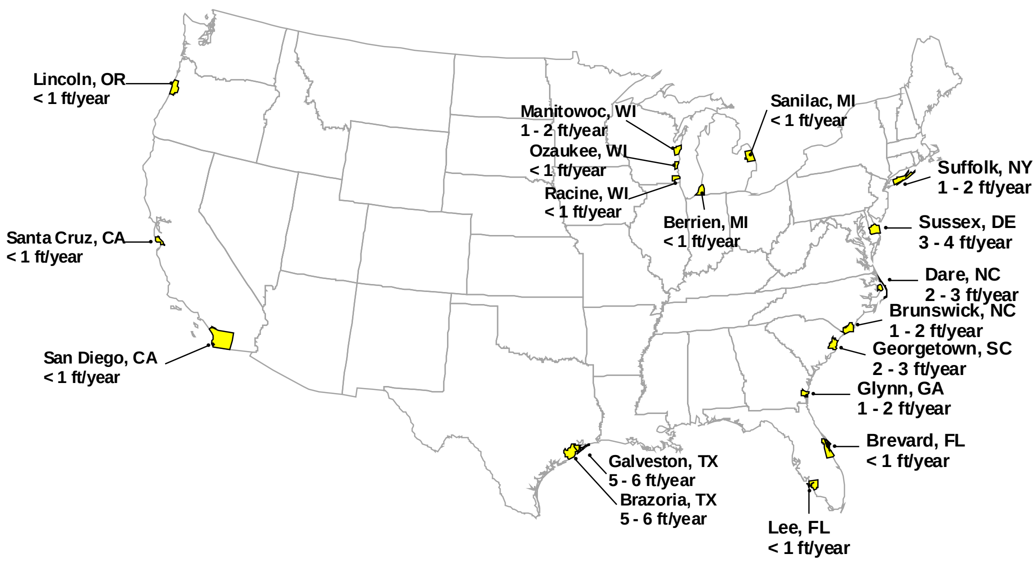
Structures were sampled within representative sampling transects distributed throughout the entire length of mapped coastline.[3] The transects included both eroding and non-eroding areas, as well as varying flood heights and zone designations (e.g., V-zone, A-zone, and X-zone). Using the Global Positioning System and conventional survey techniques, the surveyors located the latitude and longitude coordinates of each structure accurate to within 3 feet and the vertical elevation of the lowest floor accurate to within 6 inches.

Detailed structure and parcel attribute information was obtained from each local government's tax assessment office. This information was combined with the field survey data and plotted on the 60-year EHA maps in a geographic information system. A description of attributes collected or calculated for each structure is provided in Appendix C.

The NFIP policies in force and claims data from the Federal Insurance Administration for the 27 counties mapped by FEMA also were obtained. Detailed property attributes, such as sales price and interior features, were acquired through a mail survey of owners of field-surveyed properties. Finally, a database of coastal erosion rates and census block groups adjoining open-ocean coastlines nationwide was developed to extrapolate nationwide erosion losses and the effects of policy changes on the NFIP and coastal communities.

[3] Two counties, Sussex, DE and Glynn, GA**,** were selected as pilot tests for the field survey work and were sampled in their entirety.

FIGURE 1.1 Average Annual Erosion Rates (feet/year) within Counties studied in The Heinz Center's Evaluation of Erosion Hazards



Phase 3: Analysis of Coastal Erosion Impacts and Potential Policy Changes

The Heinz Center focused on analyzing the impacts of erosion and the effects of policy changes on the NFIP and coastal communities. The economic impact analysis included two major components: estimates of the impacts of erosion and evaluation of the impacts of possible changes in the cost and availability of flood insurance within the mapped EHAs. The first component answers the question, "How big a problem is coastal erosion?" The second component develops the "building blocks" needed to address the options suggested by the U.S. Congress in Section 577. The analysis of the impacts of erosion considered the following elements:

- value of the structures damaged by erosion,

- National Flood Insurance Fund (NFIF) compensation to policyholders for erosion-related flood losses, and
- changes in the value of residential and commercial properties in communities with erosion hazards.

The following set of policy options or "packages" (some dependent on mapping and others not), reflecting a range of possible responses to erosion hazards as broadly defined by Section 577, were evaluated:

1. maintain the status quo (i.e., no change in policy);
2. erosion mapping and dissemination alone;
3. creation of a coastal high hazard zone, including both high flood and erosion zones;
4. mandatory erosion surcharge on flood insurance in erosion zones;
5. erosion surcharge combined with regulatory measures to reduce damages;
6. flood-related regulatory changes in erosion zones;
7. erosion insurance in bluff areas susceptible to erosion but not flooding;
8. relocation assistance and/or land acquisition; and
9. shoreline protection measures (i.e., nourishment, dune restoration, and structural measures).

For each of the eight policy alternatives to the status quo, the three types of economic impacts listed above were evaluated and compared with the impacts of erosion under current policies and management regimes.

Community Responses to Coastal Erosion

As part of this study, The Heinz Center conducted five case studies of community responses to coastal erosion. The purpose of this research was to understand more fully how communities currently respond to erosion hazards in the absence of a comprehensive shoreline protection program coordinated by federal, state, and local governments; which factors influence local shoreline protection policy or management; and how changes to the NFIP would affect local efforts to manage coastal erosion. The case studies involved interviews of coastal property owners, community officials, coastal managers, environmentalists, and others affected by coastal erosion. Based on these interviews, Appendix F describes current responses to erosion, how communities might react to policy changes at the federal level, and how their concerns can be addressed. Examples from this study of community responses also can be found in Chapter 4.

REPORT ORGANIZATION

This report presents an analysis of the impacts of erosion on the NFIP, related federal programs (e.g., disaster assistance), and coastal communities (including individual property owners) as well as the potential effects of policy changes. The report includes descriptions of the nature and extent of coastal erosion hazards, the roles of insurance and the federal government in reducing erosion losses, actions and response measures for reducing erosion losses that are available to individuals and communities, and how these responses may be affected by policy changes. The other chapters of the report and the appendices address the following topics:

Chapter 2 describes the physical nature of shorelines in context with coastal development.

Chapter 3 describes the major components and history of the NFIP. The program's current approach to coastal flooding and erosion hazards is described. Past and current policy reform proposals are reviewed.

Chapter 4 reviews the decision-making context for addressing coastal erosion hazards. The current approaches to erosion management are described. The causes, effects, and distribution of erosion hazards and current federal, state, and local management policies and responses also are reviewed.

Chapter 5 analyzes the economic impact of erosion, focusing on the extent of the coastal erosion problem both today and over the next 60 years assuming that no changes to current management approaches or policies are made. Using the data obtained from the sample of 18 communities and census block groups, the total expected flood and erosion damage per $100 of house value is estimated and the results extrapolated nationwide. The effects of erosion on current house values and rates of coastal development also are explored.

Chapter 6 describes a series of possible changes in policy, analyzes the potential impact of each change, and discusses how these changes might alter the trends observed today. Floodplain management and mitigation activities, which play central roles in reducing losses from natural hazards, are addressed in this analysis. The costs and benefits of completing the mapping of EHAs nationwide (which depend on the changes, if any, to NFIP policies) are compared to benefits that would accrue from equivalent expenditures on other possible erosion and flood-related mitigation activities not requiring EHA maps. The Heinz Center's recommendations for these changes to the NFIP are presented and discussed.

Appendix A contains Section 577 of the National Flood Insurance Reform Act of 1994 which mandated the *Evaluation of Erosion Hazards* study.

Appendix B, *Coastal Erosion Hazards Study: Phase One Mapping* (Crowell et al., 1999), describes the initial phase of this study which mapped erosion hazard areas in 27 coastal counties.

Appendix C, *Field Survey of Structures and Geographic Information System Methods*, provides a detailed explanation of the collection of structure data and the resulting GIS project.

Appendix D, Economic and Actuarial Analysis Methods, contains four reports: 1) *Coastal Erosion Hazards: The University of Georgia's Results* examines the economic effects of flood insurance pricing and availability on housing values, the local community, and the coastal ecosystem; 2) *Flood Insurance, Erosion, and Coastal Development* describes how development in coastal beachfront areas is affected by erosion and the availability of federal flood insurance; 3) *Estimating Expected Damage to Structures* describes the data and methods used to estimate flood and erosion damage to structures; and 4) *Erosion Ratemaking Procedures and Tables* describes the methods used to quantify erosion losses, and shows, by region and erosion hazard zone, the amount of surcharge on existing rates needed to insure against erosion losses.

Appendix E lists the communities nationwide that are likely to be identified as having erosion hazard areas.

Appendix F, *Community Response to Coastal Erosion*, describes how communities currently deal with erosion in the absence of a comprehensive federal-state-local shoreline protection program and explores how a change in NFIP policy would impact local efforts.

Appendix G is the *Questionnaire for Property Owners*, part of the National Coastal Property Survey.

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2.

CHANGING SHORELINES OF THE UNITED STATES

The shorelines of the United States are dynamic and diverse, shaped by both natural processes and human intervention. Principal U.S. shoreline types include the following (National Research Council,1990):

- crystalline bedrock (e.g., central and eastern Maine coast);
- eroding bluffs and cliffs (e.g., the Great Lakes; outer Cape Cod; parts of Long Island, New York; the Pacific Coast);
- pocket beaches between headlands (e.g., southern New England, California, Oregon);
- strandplain beaches attached to mainland (e.g., Myrtle Beach in South Carolina);
- barrier beaches (e.g., generally along Atlantic and Gulf of Mexico coasts); coral reef and mangrove (e.g., South Florida); and coastal wetlands (e.g., Southern Louisiana, areas landward of barrier beaches).

The physical diversity of shorelines is mirrored by the varied nature and extent of the erosion problem. Coastal erosion is a complex physical process influenced by both natural factors and human activities. Natural factors contributing to erosion include sand supply; changes in sea level or Great Lakes water levels; geologic characteristics; sand-sharing systems of beaches and dunes; and the effects of waves, currents, tides, and wind. Table 2.1 lists the natural factors that affect shoreline change on the ocean coasts.

TABLE 2.1 Natural Factors Affecting Shoreline Change

Factor	Effect	Time Scale	Comments
Sediment supply (sources and sinks)	Accretion/ Erosion	Decades to millennia	Natural supply from inland (e.g., river floods, cliff erosion) or shoreface and inner shelf sources can contribute to shoreline stability or accretion
Sea level rise	Erosion	Centuries to millennia	Relative sea level rise, including effects of land subsidence, is important
Sea level variability	Accretion/ Erosion (for increases in sea level)	Months to years	Causes poorly understood, interannual variations that may exceed 40 years of trend (e.g., El Niño)
Storm surge	Erosion	Hours to days	Very critical to erosion magnitude
Large wave height	Erosion	Hours to months	Individual storms or seasonal effects
Short wave period	Erosion	Hours to months	Individual storms or seasonal effects
Waves of small steepness	Accretion	Hours to months	Summer conditions
Alongshore currents	Accretion, no change, or erosion	Hours to millennia	Discontinuities (updrift ≠ downdrift) and nodal points
Rip currents	Erosion	Hours to months	Narrow seaward-flowing currents that may transport significant quantities of sediment offshore
Underflow	Erosion	Hours to days	Seaward-flowing, near-bottom currents may transport significant quantities of sediment during coastal storms
Inlet presence	Net erosion; high instability	Years to centuries	Inlet-adjacent shorelines tend to be unstable because of fluctuations or migration in inlet position; net effect of inlets is erosional owing to sand storage in tidal shoals
Overwash	Erosion windward/ accretion leeward	Hours to days	High tides and waves cause sand transport over barrier beaches
Wind	Erosion	Hours to centuries	Sand blown inland from beach
Subsidence	Erosion	Years	Withdrawal of subsurface fluids
Compaction	Erosion/accretion	Instantaneous	(natural/human induced)
Tectonic		Centuries to millennia	Earthquakes Elevation or subsidence of plates

SOURCE: Reprinted from National Research Council (1990) with permission.

Human activities that can alter natural processes include dredging of tidal entrances, construction of jetties and groins, hardening of shorelines with seawalls, beach nourishment, and construction of harbors and sediment-trapping dams. Shoreline engineering structures, often built to protect development, can be undermined by ongoing erosion. This chapter provides an overview of shoreline characteristics by region of the United States and the impact of coastal development on the erosion problem.

The nation's shorelines are receding at an average rate of slightly more than 1 foot (ft) per year (yr), but rates vary significantly across regions and shoreline types (Leatherman, 1993). According to Galgano (1998) and Leatherman (1993), 80 to 90 percent of the sandy beaches in the United States are eroding. The East Coast erosion rate averages 2–3 ft/yr. However, these rates can vary over short distances (e.g., 1 mile or less) because of geology, inlets, and engineering structures. Two types of losses can be caused by erosional processes. The first is shoreline retreat, characterized by beach and bluff erosion that undermines structures (see Figure 2.1).

The second is increased flood damage caused by a combination of erosional processes, such as scour, and changes in beach profile that increase flood risk. It is nearly impossible, however, to separate erosion damages from flood damages because both tend to occur together during large storms (National Research Council, 1990).

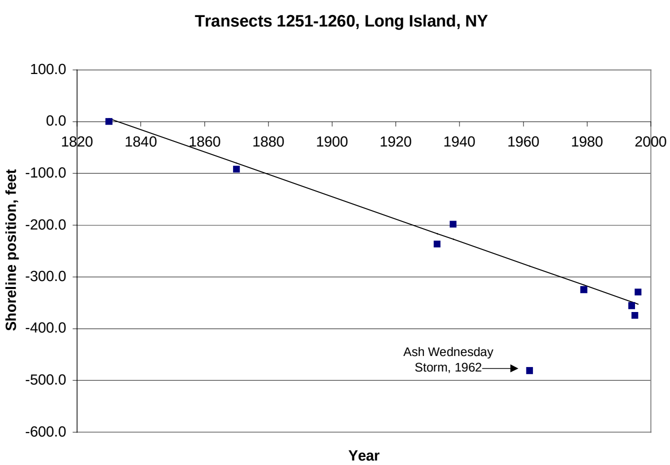
FIGURE 2.1 The shore eroded beneath this lighthouse on Morris Island, SC, placing it hundreds of feet into the ocean.

(Photo by Stephen P. Leatherman, 1989)

Severe storm events, such as hurricanes, can cause extensive vertical and horizontal erosion of the beach and primary dunes. These erosion events are followed by extended periods of accretion, in which the beach partially builds back, but often not completely, to its pre-storm position (see Figure 2.2) (Douglas et al., 1998; Zhang et al., 1997). Increased development and population growth increases the potential of a major disaster from the combined effects of hurricane force winds, coastal flooding, and erosion of beaches (Dean, 1999; Godschalk et al., 1989; Godschalk et al., 1998). Many scientists believe that rising global temperatures may change the frequency and severity of extreme weather events, leading to increasing damages in the decades ahead, although observations of hurricane frequency over the past 100 years do not reveal an upward trend (Zhang et al., 1997).

Although sediment supply and coastal storms are important factors affecting a specific reach of shoreline, sea level rise affects all shorelines and is perhaps the dominant process determining the rate of shoreline movement and position (Zhang et al., 1997). During the last century, the global average sea level has risen about 1.0 to 2.5 millimeters per year (Douglas, 1995). Because of subsidence, the average rise is approximately 1 ft (approximately 30 centimeters [cm]) per century along the Atlantic and Gulf coasts. However, some parts of Maine and the Pacific Northwest actually have experienced relative sea level decline because of post-glacial rebound or tectonic causes (Leatherman, 1993; Douglas, 1995). Other areas, such as Louisiana, are experiencing higher than average rates of sea level rise because of subsidence caused by natural processes and human activities (e.g., oil, gas, and groundwater pumping).

FIGURE 2.2 Average shoreline positions in parts of Long Island, NY have fluctuated over the past 160 years but overall have receded approximately 350 feet.



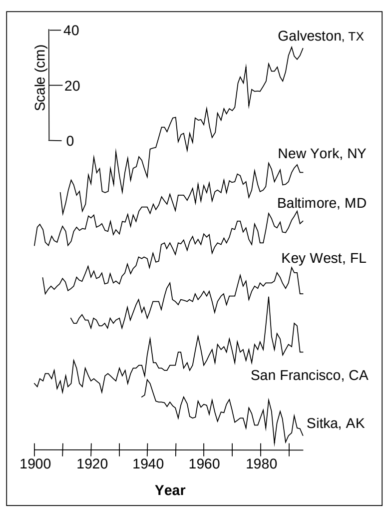
SOURCE: Florida International University Laboratory for Coastal Research, 1998

Figure 2.3 shows National Oceanic and Atmospheric Administration tide gauge data at selected U.S. cities. Although the rate of sea level rise seems relatively small—on the order of centimeters—it is still significant, because a small vertical change in water level can shift coastlines dramatically inland, depending on the slope of the coast.

Research has revealed an important relationship between sea level rise and sandy beach erosion. On the U.S. East Coast, historical time-series data show that erosion rates on sandy beaches—uninfluenced by inlets or engineering modifications—are roughly 150 times the rate of sea level rise (Leatherman et al., 1999). For example, a sustained rise of 10 cm in sea level could result in 15 meters of shoreline retreat. This amount of erosion is more than an order of magnitude greater than would be expected from a simple response to sea level rise through inundation of the shore.

At present, it is not possible to make a very confident statement about the relative contributions of specific natural and anthropogenic forcings to observed climate change (Barnett, et al., 1999). The Intergovernmental Panel on Climate Change projects a global rise in sea level of between 15 cm and 95 cm, with a "best estimate" of roughly 50 cm by 2100 (Houghton et al., 1996). These estimates imply that current rates of sea level rise will accelerate in the future; this will exacerbate the present erosion problem by increasing the rate of beach loss (see Box 2.1). However, the seriousness of coastal erosion calls for urgent action irrespective of possible acceleration in sea level rise.

FIGURE 2.3 U.S. sea levels generally have been rising during this century (1900–1997), although there are some isolated exceptions, such as Sitka, Alaska, which are generally related to tectonic uplift of the land.



SOURCE: Titus, 1998.

BOX 2.1 Sea level rise and coastal erosion

Observed rates of sea level rise

Global mean surface temperature has increased by between about 0.3 and 0.6°C since the late 19th century. Over the past 100 years, global sea level has risen between 10-25 cm (about 6 inches), primarily in response to thermal expansion of the oceans and melting of mountain glaciers. The mean trend for global sea level rise was about 1.9 mm/year. Regional sea level changes differ from the global mean value for many reasons, such as tectonic uplift or subsidence of the land surface (see Figure 2.2).

Projected rates of sea level rise

Average sea level is projected to rise somewhat more rapidly because of thermal expansion of the oceans and melting of glaciers and ice-sheets induced by greenhouse gases. According to the IPCC's "business as usual" scenario, sea level is projected to rise by 20 cm by the year 2050, within a range of uncertainty of 7-39 cm (Houghton et al., 1996). The IPCC "business as usual" projection for global mean sea level rise for the next 50 years is roughly 10 cm higher than might be expected from the trends of the last 100 years. Most of the projected rise in sea level is because of thermal expansion, followed by increased melting of glaciers and ice caps.

Implications for erosion hazard areas

Sandy beaches retreat landward in response to sea level rise. On the Atlantic Coast, long-term shoreline retreat has averaged about 150 times that of sea level rise (Leatherman et al.,1999). Thus, a sustained rise of an additional 10 cm in sea level could result in 15 meters (about 50 feet) of beach erosion. Absent protective measures (e.g., shoreline armoring or beach nourishment), an accelerated rate of sea level rise would result in increased rates of inland shoreline retreat.

The 60-year erosion maps prepared for this study are based upon historical shoreline records that typically date from the 1930s or earlier. These projections reflect historical rates of sea level rise but do not incorporate the IPCC's estimates for future rates of sea level rise. Using the IPCC sea level rise estimates would increase the rate of shoreline movement by about 1 ft/yr. For comparison, erosion rates along the Atlantic Coast averaged 2-3 ft/yr over the last century. Thus, more existing structures would be vulnerable to erosion damage over the next 60 years than forecasted in this report.

However, the forecasted rates of sea level rise are based on highly uncertain assumptions regarding rates of thermal expansion of the oceans, melting or accumulation of ice cover, and surface water and ground water storage. Tide gauge records show no statistically significant evidence suggesting global warming has *accelerated* sea level rise over the past 100 years (Douglas, 1992; Houghton et al., 1996). Short term variations in sea level that endure for a decade or more can distort evidence of sea level rise acceleration. The range of uncertainty within sea level rise forecasts is expected to narrow as techniques for measuring and modeling changes in sea level, climate, and ice sheets improve.

REGIONAL CHARACTERIZATION OF EROSION AND RELATED HAZARDS

Coastal erosion hazards and the vulnerability of development and infrastructure vary significantly by geographic region in the United States. Five distinct coastal regions—Atlantic and Gulf, Pacific, Great Lakes, Hawaii, and Alaska—are described below.

Atlantic and Gulf Coasts

The Atlantic Coast, which spans approximately 3,300 miles (mi) (Federal Emergency Management Agency, 1989), is composed of two parts: the glacial northeast, extending from Maine to northern New Jersey; and the coastal plain, extending southward from New Jersey to Florida.[4] The cliffs along southern New England generally are composed of eroding glacial deposits, with some exceptions, such as the rocky headlands in Northern Maine; Point Judith, Rhode Island; and Cape Anne, Massachusetts. Much of the New England coast is relatively stable, or has erosion rates of less than 1 ft/yr. However, in Massachusetts, long-term erosion rates average approximately 3 ft/yr along the outer shore of Cape Cod, and often exceed 6 ft/yr along the south shore of Martha's Vineyard and 8 ft/yr along the south shore of Nantucket Island. Coastal erosion is a continuing problem along the shores of northern New Jersey and New York, which are among the most urbanized in the country. Much of the developed shoreline of New Jersey has been stabilized with seawalls and other armaments, which in some areas have caused extensive beach loss (Bush et al., 1996).

The Gulf Coast extends for 2,100 mi (Federal Emergency Management Agency, 1989) and is the lowest-lying area in the United States. States bordering the Gulf of Mexico have the highest average erosion rates (about 3 ft/yr) in the nation. Within the region, Louisiana has by far the most dynamic coastline and, at up to 50 ft/yr, holds the distinction of having the most rapid erosion rate in the nation (Dolan et al., 1985). This is largely a result of regional subsidence and changes in sediment delivery. The state of Louisiana has only two recreational beaches, Grand Isle and Holly Beach. Although Grand Isle was nourished recently, the high cost of sand relative to the value of the property to be protected likely will preclude any future projects. Texas has the most extensive sandy coastline in the Gulf, but much of the area is neither inhabited nor easily accessible. The city of Galveston has been effectively protected by a nearly century-old seawall and landfill, but the natural beach in front of the seawall has been lost (National Research Council, 1990) (see Figure 2.4). The west end of Galveston County and other areas, however, are not protected and are vulnerable to erosion and flood hazards.

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[4] Shore miles are measured as length of open-ocean coastline, as defined by the Federal Emergency Management Agency (1989), and include bay shorelines (e.g., Chesapeake Bay, Delaware Bay, Long Island Sound).

FIGURE 2.4 The city of Galveston, Texas, is protected by a seawall but has lost its natural beach.

(Photo by The Heinz Center)

Barrier islands are the most dynamic land masses along the open-ocean coast. They consist of a chain of roughly 300 separate, low-lying islands that line the Gulf and Atlantic coasts from Maine to Texas. Barrier islands are composed primarily of loose sand and are subject to multiple natural hazards, including flooding, wind, waves, and sediment transport, as well as extreme storm events and long-term sea level rise. Barrier island coastlines also have been retreating landward for thousands of years in response to slowly rising sea levels. They have been maintained, albeit in more landward positions, through processes of inlet movement, overwash, and dune migration (Leatherman, 1988).

The change in shoreline position at the Cape Hatteras lighthouse in North Carolina illustrates the problem of long-term erosion of barrier islands (see Figure 2.5). When constructed in 1870, the lighthouse was 1,500 ft from the shore. Protective measures to reduce the rate of beach erosion in front of the lighthouse provided a temporary solution, but, by late 1987, the lighthouse stood only 160 ft from the sea and was in danger of collapsing because the erosion rate had averaged 15 ft/yr (National Research Council, 1988). In 1999, after years of debate and lawsuits aimed at blocking a relocation, the National Park Service successfully moved the lighthouse back 2,900 ft at a cost of $9.8 million (National Park Service, 1999).

The Atlantic and Gulf coasts are at great risk from storm-related erosion because they are vulnerable to hurricanes as well as winter storm events. Total insured property exposures for this region have increased by 70 percent since 1988 (Insurance Research Council and Insurance Institute for Property Loss Reduction, 1995), and financial exposures are expected to continue to rise as the coastal population and economic activity increase. Hurricane Hugo, which struck the coast in 1989, caused $7 billion in damages to coastal properties in

North Carolina and South Carolina (National Oceanic and Atmospheric Administration, 1990). Prior to Hugo, the insurance industry never had incurred a loss from a single disaster that exceeded $1 billion in damages (Kunreuther, 1998).

FIGURE 2.5 Coastal erosion threatens the foundation of the Cape Hatteras lighthouse, as shown in (a); in response, it was relocated back from the ocean in 1999, as shown in (b).

(a) 1989 - The ocean encroaches upon the Cape Hatteras lighthouse, built in 1870.

(Photo by David Policansky)

(b) 1999 - Ten years later, the National Park Service moved the Cape Hatteras lighthouse back 2,900 feet.

(Photo by Drew Wilson, The Virginia Pilot)

In 1992, Hurricane Andrew became the most costly storm-related disaster in U.S. history, with (mostly wind-related) damages exceeding $15 billion (Insurance Research Council and Insurance Institute for Property Loss Reduction, 1995). Scientists point out that the past two decades have been a relatively quiet period for Atlantic hurricane activity; however, some researchers believe that a new cycle of increased hurricane activity has begun, ushered in by hurricanes Georges and Mitch in 1998 (Gray et al., 1999).

Table 2.2 shows the frequency of hurricane landfalls by Saffir-Simpson Category on the mainland United States between 1899 and 1999. Over short periods of time, the actual number and timing of landfalls and passages may deviate substantially from the long-term average; some years have little tropical cyclone activity, whereas other years might have a number of landfalls.

Pacific Coast

The Pacific coastline of the conterminous United States (California, Oregon, and Washington) extends for 1,700 mi (Federal Emergency Management Agency, 1989) along the open ocean and encompasses a wide range of shore types, including mainland beaches, pocket beaches, bluffs and cliffs, and lagoons and river channels. Much of the Pacific coastline consists of narrow beaches backed by steep sea cliffs that are composed of crumbly sedimentary bedrock and are therefore unstable. In addition, the cliffs are heavily faulted and cracked, and the resulting breaks and joints are undermined easily by wave erosion (Flick and Sterrett, 1994). The majority of cliff erosion occurs in episodic events, such as severe winter storms, high rainfall, high tides, and elevated sea levels, especially during El Niños (Flick and Cayan, 1984; Seymour et al., 1985). Landslides triggered by earthquakes, groundwater seepage, or other geologic processes also can cause bluff failures. Cliff erosion is site specific and episodic. In some locations, the cliffs have retreated tens of feet, whereas 50 to 100 ft away, there is no retreat at all (Kuhn and Shepard, 1984). As a result, long-term average annual erosion rates are usually less than 1 ft/yr, but these low averages hide the true nature of large, episodic events.

Coastal storms also play a significant role in the erosion of beaches and coastal cliffs. The El Niño winter of 1982–1983 set the stage for severe storm-induced erosion damage to structures along the California coast. It caused over $100 million in coastal property damages, including the loss of 33 oceanfront homes, damage to 300 more houses and 900 businesses, and $35 million in losses to coastal public recreational infrastructure (Flick, 1998). The 1997–1998 El Niño again caused extensive erosion of Pacific Coast beaches and left many cliff-top buildings increasingly exposed to storm- and erosion-related losses.

TABLE 2.2 Hurricane Direct Hits on the Mainland U.S. Coastline and for Individual States from 1899-1999 (by Saffir-Simpson Category[a])

Area	Category Number					All	Major
	1	2	3	4	5	1,2,3,4,5	3,4,5
U.S. Total (Texas to Maine)	58	36	47	15	2	158	64
Texas	12	9	9	6	0	36	15
(North)	7	3	3	4	0	17	7
(Central)	2	2	1	1	0	6	2
(South)	3	4	6	1	0	14	7
Louisiana	9	5	8	3	1	26	12
Mississippi	1	1	5	0	1	8	6
Alabama	4	1	5	0	0	10	5
Florida	17	16	17	6	1	57	24
(Northwest)	10	8	7	0	0	25	7
(Northeast)	2	7	0	0	0	9	0
(Southwest)	8	3	6	2	1	20	9
(Southeast)	6	10	7	4	0	27	11
Georgia	1	4	0	0	0	5	0
South Carolina	6	4	2	2	0	14	4
North Carolina	10	5	11	1 [b]	0	27	11
Virginia	2	1	1 [b]	0	0	4	1 [b]
Maryland	0	1 [b]	0	0	0	1 [b]	0
Delaware	0	0	0	0	0	0	0
New Jersey	1 [b]	0	0	0	0	1 [b]	0
New York	3	1 [b]	5 [b]	0	0	9	5 [b]
Connecticut	2	3 [b]	3 [b]	0	0	8	3 [b]
Rhode Island	0	2 [b]	3 [b]	0	0	5 [b]	3 [b]
Massachusetts	2	2 [b]	2 [b]	0	0	6	2 [b]
New Hampshire	1 [b]	1 [b]	0	0	0	2 [b]	0
Maine	5 [b]	0	0	0	0	5 [b]	0

[a] The disaster potential of hurricanes is rated according to the Saffir-Simpson Hurricane Scale. Categories 1 and 2 are relatively minor, with sustained winds of 74 to 110 miles per hour (mph); Categories 3 through 5 are major, with sustained winds greater than 111 mph.
[b] Indicates all hurricanes in this group were moving faster than 30 mph.

Note: State totals will not necessarily equal U.S. totals, and Texas or Florida totals will not necessarily equal sum of sectional totals because of multiple hurricane landfalls.

SOURCE: NOAA, 1997, with 1997 -1999 landfall hurricane data from National Hurricane Center

Great Lakes

The Great Lakes coasts extend for 3,600 mi (Federal Emergency Management Agency, 1989), and are composed of a variety of shore types, ranging from high rock bluffs to low plains and wetlands. Coastal erosion in the Great Lakes is affected by many factors, including cyclically changing lake levels, disruption of longshore transport of beach building material, and storms. Rates of bluff and dune erosion along the shores of the Great Lakes vary from near zero to tens of feet per year because of annual variability in wave climate and lake levels (National Research Council, 1990). The Great Lakes have experienced a series of high lake levels in the past two decades, with the highest peak occurring in 1987 (U.S. Army Corps of Engineers Detroit District, 1997). High lake levels increase bluff recession rates by increasing wave attack on the base of the bluff.

In many areas of the Great Lakes, bluff erosion produces beach-building sediments. However, both tributary and shoreland sources of sediment are depleted by navigational improvements and dredged material disposal practices, which remove these sediments from the littoral system. Ice ridges that form and break up each winter along the shoreline also cause erosion by trapping sand in floating fragments of ice that are carried offshore into deep water. This continuing natural process is one of the principal mechanisms by which sand is lost from the nearshore system (U.S. Geological Survey, 1992). The hardening of the lakeshore with erosion control structures can also reduce sediment supply and adversely affect natural processes.

Hawaii

Coastal erosion is a widespread and locally severe problem in the Hawaiian Islands, which have 500 mi of coastline (Federal Emergency Management Agency, 1989), and elsewhere in the Pacific tropical region. The Hawaiian coastline is susceptible to high waves associated with hurricanes, tsunamis, and large seasonal swells that can cause extensive short-term erosion. The average long-term erosion rate in Hawaii is less than 1 ft/yr (Coyne et al., 1998). Human activities have aggravated coastal erosion problems on the Hawaii coastline by restricting sediment supply and reducing beach width. Erosion protection measures have focused on constructing shoreline-hardening structures, such as revetments and seawalls (Coyne et al., 1998). Hardening the shoreline restricts the transport of sand located landward of the vegetation line, thus starving the beach of a sand supply and possibly leading to total beach loss (Hanson and Kraus, 1986; Bush et al., 1986). The mean beach width along armored shorelines is half of the mean beach width adjacent to unarmored, freely migrating shorelines (Fletcher, 1997). Beach nourishment and restoration activity is limited to Waikiki Beach on Oahu, a popular tourist destination, but efforts are under way to extend that practice (Coyne et al, 1998).

Alaska

Alaska's 6,600-mile coastline (excluding bays and fjords) is subject to periodic, yet severe, erosion (United Nations Conference on Environment and Development, 1992). Alaska's northern coastline is icebound for most of the year. The ice season lasts from November to April on most of the Bering Sea coast, longer along the Chukchi Sea, and still longer on the Beaufort Sea coast, where it usually lasts 9 to 10 months (Weller and Anderson, 1998). Along this northern coastline, Alaska experiences some of the highest erosion rates in the world during its few ice-free months (National Research Council, 1995). The high coastal erosion rates generally are caused by seasonal storm surges, the thawing of permafrost, and the breaking off of chunks of shoreline by moving ice; some of the area's barrier islands are moving landward at a rate of 23 ft/yr (Williams et al., 1995). Other geologic forces such as earthquakes, landslides and land subsidence contribute to the state's erosion problems. In 1964, an earthquake caused huge landslides in Anchorage. In coastal areas surrounding the city, enormous blocks of earth that had been stable for years fell into the sea as the unconsolidated gravel and clay beneath them gave way. Fortunately, there are few if any houses or structures at risk from erosion along this largely barren coastline.

COASTAL DEVELOPMENT AND EROSION HAZARDS

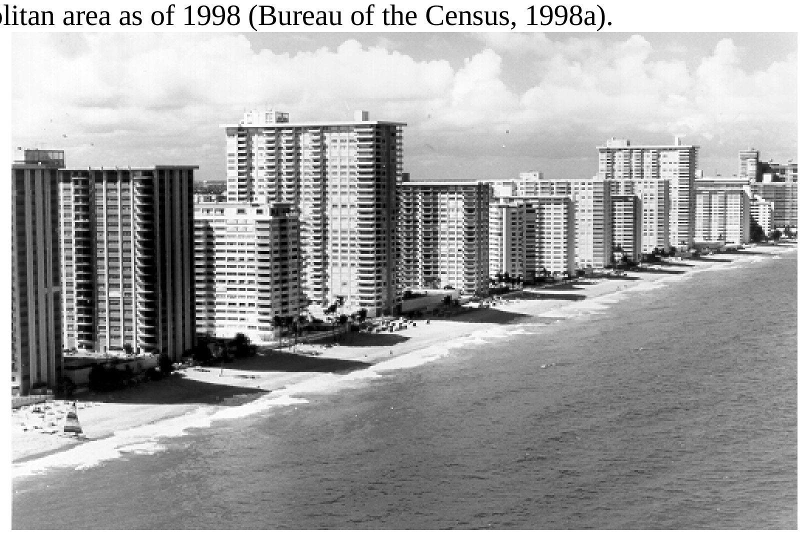
Coastal areas are a popular destination for tourism and recreational activities. Each year, approximately 180 million Americans spend approximately $74 billion on visits to ocean and bay beaches (Houston, 1996). U.S. coastlines also have growing appeal as international tourism destinations (Houston, 1996; National Oceanic and Atmospheric Administration, 1998). Waterfront property values and vacation rental rates are substantially greater than those of non-waterfront properties, making the ocean and Great Lake coasts attractive locations for second homes and investment properties.

Coastal development and loss of property from storm surge, wind, erosion, and related hazards are ongoing problems that date back to the early history of the United States (Leatherman, 1991). Although erosion rates and storm activity have varied over time, coastal populations, development, and infrastructure have increased dramatically since World War II. Within the United States, coastal counties have grown at a rate equal to or greater than the national average (National Oceanic and Atmospheric Administration, 1998). Beginning in the 1950s, rising incomes, improvements to transportation infrastructure and access, increased automobile ownership, and more leisure time made coastal vacationing desirable for a growing proportion of the population. Proximity to urban areas was, and continues to be, a major factor influencing the rate and nature of coastal development. At the same time, access to shore communities has improved greatly. Bridges, causeways, and other infrastructure (e.g., utilities, sewers) were primary factors in determining the location and rate of development in coastal communities (Cordes and Yezer, 1995; Bush et al., 1996). These and other factors transformed many beach communities from sparsely developed summer camps and fishing villages into moderately to densely populated areas, despite the presence of natural hazards such as erosion, flooding, and wind (Burton et al., 1969) (see Figure 2.6). This rapid increase in coastal development began well before the National Flood Insurance Program (NFIP) was implemented in the early 1970s.

Approximately half a million people live within 500 ft of the 10,000 mile long ocean and Great Lakes shorelines of the lower 48 states and Hawaii. Table 2.3 shows the geographic distribution of coastal population within this narrow corridor by region and state. This estimate is based on an analysis of "block group level" housing data, the most detailed publicly available information from the 1990 census (Bureau of the Census, 1998b). The data shown exclude the densest parts of urban areas (e.g., Miami, New York, Los Angeles, Chicago), which are heavily protected from erosion.

Extensive development has occurred in coastal areas and the trend continues. Approximately 350,000 structures are located within 500 ft of the shoreline (again, excluding the densest parts of urban areas). A large potential for investment return, combined with favorable tax laws and the common desire to own beachfront property for personal use, creates strong incentives for individuals to maximize existing and future shorefront development. Likewise, communities see benefits in allowing development in the form of a larger tax base and increased tourism revenues.

FIGURE 2.6 High-rise buildings line North Miami Beach, Florida. A "City on the Beach," approximately 3.7 million people lived in the Miami – Fort Lauderdale metropolitan area as of 1998 (Bureau of the Census, 1998a).



(Photo by Stephen P. Leatherman, 1995)

TABLE 2.3 U.S. Population Within 500 Feet of the Shoreline, 1990[a]

Region	State	Population[b]	Total
Atlantic	Connecticut	7,000	
	Delaware	1,000	
	Florida	81,000	
	Georgia	1,000	
	Massachusetts	36,000	
	Maryland	1,000	
	Maine	4,000	
	North Carolina	5,000	
	New Hampshire	1,000	
	New Jersey	19,000	
	New York	6,000	
	Rhode Island	5,000	
	South Carolina	6,000	
	Virginia	3,000	176,000
Great Lakes	Illinois	14,000	
	Indiana	3,000	
	Michigan	34,000	
	Minnesota	3,000	
	New York	13,000	
	Ohio	26,000	
	Pennsylvania	3,000	
	Wisconsin	17,000	115,000
Gulf of Mexico	Alabama	3,000	
	Florida	41,000	
	Louisiana	300	
	Mississippi	9,000	
	Texas	2,000	56,000
Pacific Coast	California	158,000	
	Oregon	5,000	
	Washington	17,000	179,000
Hawaii	Hawaii	29,000	29,000
Grand Total			555,000

[a] Data shown exclude the densest part of urban areas
[b] Numbers are rounded to nearest thousand.

SOURCE: Adapted from Bureau of the Census, 1998b. Analysis of 1990 U.S. census block groups by The Heinz Center.

The costs of natural disasters are rising as more people and structures are exposed to hazards (Kunreuther, 1998; Godschalk et al., 1998). Between 1980 and 1998, 14 severe storms (12 hurricanes, 1 Nor'easter, and 1 tropical storm) caused damages to coastal areas of the United States exceeding $1 billion each. In aggregate, these storms caused approximately $35 billion in damages (unadjusted for inflation) and 339 deaths (National Oceanic and Atmospheric Administration, 1999). In addition, numerous smaller tropical and extratropical storms caused a great deal of damage. For example, Tropical Storm Frances, which struck the Gulf of Mexico in October 1998, caused $256 million in damages in Galveston County, Texas (Figure 2.7). Lax enforcement, a lack of incentive to provide protective measures in some communities, and the varying degrees of success achieved through structural shoreline protection have increased the probability that losses will be increasingly severe in future flood disasters (National Research Council, 1990, 1995; Kunreuther, 1998).

FIGURE 2.7 Frances, a tropical storm in 1998, caused extensive damage in one Texas county.

(Photo by The Heinz Center)

A recent study by The Heinz Center (1999), *The Hidden Costs of Coastal Hazards*, points out that an improved understanding of the costs of coastal hazards is essential for accurate risk assessment and wise investment of mitigation dollars. The study emphasizes that many hidden or unreported costs related to coastal hazards are imposed on the business community, individuals, families and neighborhoods, public and private institutions, and natural resources and the environment. Although that study focused on weather-related coastal hazards, such as hurricanes and other severe storms, erosion clearly influences the stability and condition of coastal property when such disasters strike a community (see Box 2.2).

Demographic changes in the United States also have played a significant role in the development of beachfront property and coastal communities. Beach visitation and recreation always have been popular activities, but until prior to World War II, access to coastal resort areas was limited and the few vacation-oriented coastal communities that did exist were near large urban centers, such as Avalon, New Jersey, and Galveston, Texas. At that time, many coastal communities were settled primarily by fishers and marginal farmers and included some of the poorest areas in the nation (National Oceanic and Atmospheric Administration, 1998). In remote, little developed areas, it was not uncommon for coastal counties to give away barrier island land as an additional incentive to buyers of mainland property within the county. Currituck County in North Carolina, for example, gave away barrier island property on the Outer Banks to farmers purchasing tracts on the mainland. The U.S. government purchased several barrier islands (e.g., Chincoteague Island, Maryland) and converted them into parkland because they had no value for farming and were inaccessible for commerce or trade (Leatherman, 1997).

Important social, cultural, and environmental values attract people to the shore. People visit and live near the coast for many reasons, including tourism, fishing, surfing, and other recreational activities (U.S. Environmental Protection Agency, 1995). Coastal areas are aesthetically pleasing places for renewal and relaxation and offer diverse recreational opportunities, open space, and a milder and more moderated climate (in certain seasons) than is typical of inland areas.

Conservation of coastal habitats and maintenance of coastal ecosystem services which can be severely impacted by erosion are growing priorities at the local, state, and federal levels. Coastal habitats contain a wealth of biological diversity and habitat types, including wetlands and estuaries, beaches and dunes, and uplands. In the United States, coastal ecosystems support 45 percent of all species listed as threatened and endangered, including three-fourths of the federally listed birds and mammals (U.S. Fish and Wildlife Service, 1995). Estuaries and wetlands provide important nursery habitat for fisheries, buffer upland areas from the effects of storms and flooding, filter water, and reduce erosion of coastlines by acting as a buffer. Coastal ecosystems support nearly two-thirds of all fisheries and half of migratory songbirds, and—despite increased development—comprise one-third of the nation's total wetland acreage (U.S. Fish and Wildlife Service, 1995).

Decisions about coastal land use and rebuilding are influenced by general awareness of, and responses to, coastal hazards. Individual awareness of coastal hazards and understanding of erosion processes have improved over the past three decades. Early research by Mitchell (1974) and Rowntree (1974) found that residents of coastal communities had only a modest awareness of coastal hazards and a poor understanding of the processes contributing to coastal erosion. Almost 25 years later, Ives and Furuseth (1988) found that coastal residents were cognizant of erosion, viewing it as “a continuous, natural process with which they must cope.” In their survey, more than 80 percent of the respondents indicated that they liked their communities and would not leave because of beach erosion. Similarly, Miller (1992) found that coastal property owners were knowledgeable about flood and erosion risks when they purchased their properties. It is uncertain, however, whether awareness of the erosion hazard is sufficient to stimulate changes in land use and siting of new development (and redevelopment) is uncertain. The effect of information programs, such as erosion hazard disclosure requirements, is explored in Chapter 6.

Coastal property owners express strong emotional attachment to their properties and place psychological value on the oceanfront amenities. They prefer, if possible, to redevelop or repair a structure damaged by flooding or erosion rather than relocate or demolish it. Coastal property owners who have been forced to relocate often move a structure only the minimum distance required by law to protect it from immediate danger (i.e., not as far back on the lot as possible) so as to maximize their views and other amenities (see Appendix F). Property owners repeatedly have indicated a strong preference for building and rebuilding as close to the oceanfront as possible, despite the threat of floods, erosion, and other hazards (Ives and Furuseth, 1988; Miller, 1992; Platt, 1998a).

BOX 2.2 The Costs of Beach and Dune Restoration in the Carolinas after Major Hurricanes

Severe storms and chronic erosion can, and often do, cause extreme damage along the shoreline, including a loss of beach sand offshore or downdrift, undermining or overwashing of the dunes that protect uplands, or, in extreme cases, the cutting of new ocean inlets. In locations where beaches are backed up by bluffs, beach erosion leads to bluff undermining, slumping, and upland property loss. Once a beach or dune is lost, its capacity to buffer the next storm is reduced dramatically. Following major erosion events, the recreational value of beaches declines sharply, because of both reduced beach area and loss of aesthetic appeal. Local tourist dollars are lost altogether or transferred elsewhere.

North Carolina

Hurricane Fran, which struck Topsail Island, North Carolina, caused significant erosion damage to the built environment, mostly because the natural buffering capacity of the beach and dune system had been damaged previously by Hurricane Bertha. FEMA paid $4.6 million in Public Assistance (PA) funds to restore a “five-year berm” along 15 miles of Topsail Island, creating a low (4-5 foot) sand ridge of various grain size and color along the landward edge of the beach just in front of the building line (Platt, 1998b).

South Carolina

Many of these beach and dune impacts—as well as costs—had been experienced after Hurricane Hugo in 1989. The storm caused serious beach and dune erosion along 65 miles of South Carolina’s coast. As a result of the beach flattening, the beach widened to nearly 500 feet in some locations, more than twice its normal width. With such a flat profile and lack of dunes, many properties that were not destroyed by Hugo were considered at high risk after the storm. This situation provided the impetus for an emergency beach and dune restoration program to provide immediate protection for threatened inland properties and, eventually, efforts to restore the recreational beach.

Following Hugo, South Carolina and the federal government joined in a beach and dune system restoration that had three phases: beach scraping and dune shaping, beach nourishment, and dune revegetation. This effort cost $9.8 million, comparable to the cost of all South Carolina beach nourishment projects combined between 1980 and 1988 (Kana, 1990). The state covered approximately 60 percent of these costs, with the federal government (Federal Emergency Management Agency, U.S. Army Corps of Engineers, and taxpayers nationally) picking up the rest. The return on investment is likely to be high. By comparison, the annual benefits of coastal tourism in South Carolina are estimated at $5 billion annually (Kana, 1990), and beaches are one of the principal attractions.

A number of lessons can be learned from South Carolina’s experience with beach and dune erosion and subsequent restoration. Some of these relate to beach processes. Major storms such as Hugo are rare, but they intensify or accelerate normal processes, causing permanent coastal changes. However, much of the erosion observed after storms reflects a temporary shift of sand to offshore bars. Most of that sand will likely return to the beaches, although some may be lost permanently, either downdrift or offshore. With respect to shoreline development, one of the lessons from Hugo (as well as chronic, less powerful storms) is that judicious construction setbacks, elevation of buildings above expected storm surge heights, and soft stabilization can protect inland property while preserving options for beach and dune protection and post-storm restoration (Kana, 1990).

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3.

THE NATIONAL FLOOD INSURANCE PROGRAM

The National Flood Insurance Program (NFIP), established in 1968 to deal with the growing costs of flood disasters to federal, state, and local governments, has become the primary federal program to reduce the nation's flood losses. It was created "to provide flood insurance in communities which adopt and adequately enforce floodplain management ordinances that meet minimum NFIP requirements" (National Flood Insurance Act [NFIA] of 1968 (P.L. 90-448), *United States Code*, Title 42, Section 4001 et seq.)[5]. The National Flood Insurance Fund (NFIF), paid for from NFIP policyholder premiums, is the primary resource used to cover insurance losses as well as most of the administrative and operating expenses of the program. The two other major components of the NFIP are the identification and mapping of flood risks and hazard mitigation (i.e., actions taken to protect people and property from future flood losses).

The NFIP was established by the U.S. Congress because no affordable private insurance was available to homeowners to cover flood damages. There is no comparable insurance program in any other country. After Hurricane Betsy in 1965, the Southeast Hurricane Disaster Relief Act (P.L. 89-339) required the Department of Housing and Urban Development (HUD) to study alternatives to post-disaster relief to provide aid to flood victims (Platt, 1994; Pasterick, 1998). The resulting 1966 HUD report recommended the establishment of a federal insurance mechanism with two equally important objectives: "to help provide financial assistance for victims of flood disasters to rehabilitate their property;

[5] Henceforth, references to the *Code* will be abbreviated using the format 42 USC §4001.

and help prevent unwise use of land where flood damages would mount steadily and rapidly" (U.S. Department of Housing and Urban Development, 1966).

A companion report by the U.S. Interagency Task Force on Federal Flood Control Policy (1966) suggested an experimental federal flood insurance program, not only to reduce flood losses but also to promote wise use of floodplain areas. The report recommended that such a program be undertaken only on a trial basis until it was determined that an insurance mechanism would not lead to increased floodplain occupancy and flood losses. It pointed out that an insurance program, if misapplied, could "aggravate rather than ameliorate the flood problem" (U.S. Interagency Task Force on Flood Control Policy, 1966). To date, there has not been a full assessment of the NFIP's effects. Plans for the first comprehensive assessment were announced in 1999.[6]

PROGRAM OVERVIEW AND CURRENT STATUS

The NFIP provides federal flood insurance in exchange for the adoption of local floodplain management ordinances and the implementation of minimum flood mitigation measures (42 USC §4001 et seq.). The program consists of three components: the identification and depiction of flood risks, the insurance itself; and hazard mitigation requirements and activities in communities that want federally backed flood insurance. In addition, FEMA's Disaster Relief and Recovery Program provides assistance for emergency relief and reconstruction, coordinates all other federal agency relief efforts, and provides reconstruction relief to communities through the Public Assistance Program and to individuals through the Disaster Housing Program and Individual and Family Grants. Under both the insurance and the disaster relief programs, FEMA provides assistance to states and municipalities to develop and implement mitigation strategies.

Through detailed engineering studies, FEMA prepares maps of flood risk in each participating community. Flood risk zones are delineated into special flood hazard areas (SFHA) and non-special flood hazard areas (non-SFHA). The SFHAs show the Base Flood Elevation (BFE), which is defined as the elevation of a flood that has a 1 percent chance of occurring in any given year, also known as the 100-year floodplain. They include A-zones and V-zones. Although both zones are subject to inundation by 100-year flooding, V-zones (or high-velocity zones) are also subject to high-velocity wave action from coastal storms and seismic sources, whereas in A-zones wave action either does not occur or is less than 3 feet (ft) high (*Code of Federal Regulations*, Title 44, Section 1.1)[7].

On Flood Insurance Rate Maps (FIRMs), flood hazard area designations appear

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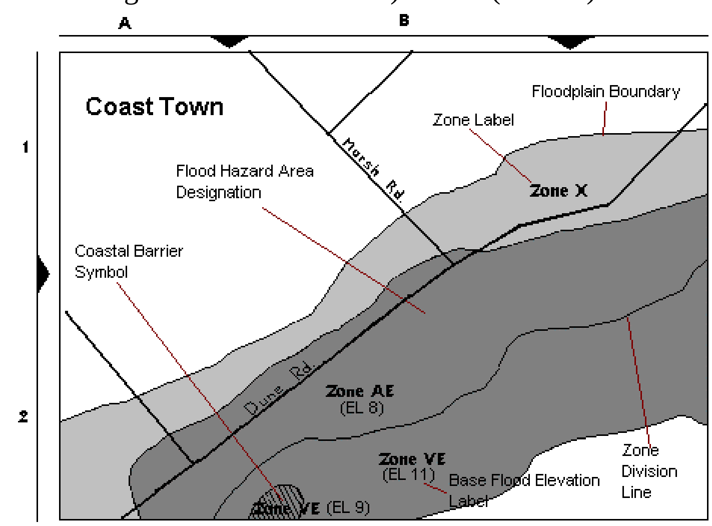
[6] The announcement was made by the administrator of the Federal Insurance Administration at the Natural Hazards Workshop in Boulder, Colorado, on July 12-13, 1999.

[7] Henceforth, references to the *Code* will be abbreviated using the format 44 CFR §1.1.

as dark and light tints. Dark tints indicate V- or A-zones, or special flood hazard areas; light tints indicate B-, C-, or X-zones, or areas of moderate to minimal flood risk, or non-special flood hazard areas. Areas excluded from NFIP coverage (e.g., units of the Coastal Barrier Resources System, described in Chapter 4) are also marked on FIRMs; erosion-prone areas, however, are not (Figure 3.1). In most coastal communities, the structures most susceptible to erosion over the next few decades are located in the V-zone, although not all V-zone structures are susceptible to erosion.

FIGURE 3.1 A schematic flood zone map of a coastal community indicates the areas where risk is high V-zone and A-zone) or low (X-zone).



SOURCE: Adapted from FEMA, 1995.

More than 19,000 communities (coastal and noncoastal) participated in the NFIP as of 1999. The regular program, which applies to a majority of these communities, begins once FIRMs are issued. Flood insurance premiums, building requirements, and floodplain management are based upon FIRMs which show the expected extent and depth of a flood and are required for every community before entry to the regular program. Prior to preparation of a FIRM, communities were eligible for an “emergency program”. Under the emergency program only limited amounts of insurance are available, but at subsidized rates, and communities only have to adopt minimal floodplain management regulations. Fewer than 3 percent of all communities participating in the NFIP today remain in the emergency program, and FEMA aims to convert them to the regular program phase as quickly as possible (Mike Robinson, Federal Emergency Management Agency, personal communication, May 10, 1999).

Once a FIRM has been issued, risk premiums vary by flood risk zone. Structures built or substantially improved (i.e., reconstructed) after FIRMs have been published are called post-FIRM structures. Post-FIRM structures built or substantially improved after December 31, 1974, and structures located outside the SFHA (100-year floodplain), regardless of the date of construction or substantial improvement, are charged unsubsidized, full-risk (i.e., actuarial) premiums. Structures built prior to the NFIP or during its preliminary phase are considered pre-FIRM structures and are "grandfathered" into the program. The program statute requires that pre-FIRM insurance policies be subsidized for the first layer of coverage (Federal Insurance Administration, 1998a; Pasterick, 1998; Frank Reilly, Federal Insurance Administration (retired), personal communication, March 28, 1999). These subsidized rates do not fully reflect the magnitude of the risk. However, pre-FIRM structures are subsidized on only the first $35,000; the remaining value of the building is insured according to actuarial rates. Box 3.1 gives examples of premium rates for a typical single family residential structure in different flood risk zones.

BOX 3.1 Coverage Limits and Premium Costs in the National Flood Insurance Program

The following type of buildings are eligible for coverage under the NFIP: residential structures including multifamily, single-family homes, townhouses/rowhouses, as well as condominium association owned structures and non-residential structures. The current maximum limit of coverage $250,000 for residential property structure and $100,000 for contents, and $500,000 for nonresidential properties for both structure and contents. The maximum amounts of flood insurance available under the emergency and regular programs are as follows:

Structure Coverage	Emergency Program ($)	Regular Program ($)
Single-family dwelling	$35,000	$250,000
Multifamily dwelling	$35,000	$250,000
Other residential	$100,000	$250,000
Nonresidential	$100,000	$500,000
Contents Coverage		
Residential	$10,000	$100,000
Nonresidential	$100,000	$500,000

The premium paid by property owners for flood insurance is affected by several factors. In general, the higher the flood risk, the higher the price of insurance. For example, the annual premium for $100,000 in building coverage for a single-family home varies depending on where the home is located. Different zones are delineated on Flood Insurance Rate Maps (FIRMs), which specify different risk areas.

- If the property is located near the ocean and therefore subject to storm surge and flooding from hurricanes and coastal storms, then the building may be in a V-zone, where structures are susceptible to damage from flooding and significant wave action. V-zones are the highest-risk areas. Premiums range from $700 to over $2,000 per year for $100,000 of building coverage, depending on elevations and year built.

- Structures located near a river, lake, stream, or certain coastal areas may be in an A-zone, an area subject to inundation by a 100-year flood event where wave action either does not occur or is less than 3 feet high. Premiums range from about $300 to $1,000 per year for $100,000 of building coverage.

- If the property is located in a low-risk area, referred to as B-, C-, X- or A99-zones, then premiums can be as low as $306 annually using standard rates. These zones are located outside the 100-year floodplain. A preferred risk policy (PRP) is available for some properties located in these areas; annual premiums for PRPs range from $106 to $326, depending on the structure.

(*continued*)

BOX 3.1, continued

Annual premiums for $100,000 of flood insurance building coverage for a residential single-family home are shown below.

Pre- or Post-FIRM[a]	Zone[b]	Other Rating Factors	Premium ($/yr)[c]	Cost per $100 of Coverage ($/yr)
Pre-FIRM	Zone V1-30, VE	No enclosure	$750	$0.75
		With enclosure	$970[f]	$0.97[f]
Post-FIRM	Zone V1-30,VE Built between 1975 and 1981	At BFE[d]	$725[f]	$0.73[f]
		1 foot below BFE	$2,180[f]	$2.18[f]
Pre-FIRM	Zone A1-30, AE	No basement	$595	$0.60
		With basement	$785[f]	$0.79[f]
Post-FIRM	Zone A1-30, AE	At BFE	$376	$0.38
		1 foot above BFE	$271	$0.27
		1 foot below BFE	$1,061	$1.06
Pre-FIRM	Zone AO, AH	With certification[e]	$201	$0.20
		Without certification	$585	$0.59
Pre/Post-FIRM	Zone B, C, X, A99	No basement	$306	$0.31
		With basement	$391	$0.39

[a] Flood Insurance Rate Map. Whether a structure is pre- or post-FIRM is determined by comparing the date of building construction to the date of the initial FIRM.
[b] Older maps use numbered A-zones (e.g., A1, A2, A30) and numbered V-zones (e.g., V1, V2, V30); newer maps use fewer zone designations for purposes of simplicity.
[c] Premium values are based on total written premium plus expense constant, federal policy fee, and increased cost of compliance premium. Effective date: May 1, 1998.
[d] Base flood elevation (found on a Flood Insurance Rate Map), which is the surface water elevation that corresponds to a 1 percent annual chance of flood.
[e] Certification can be determined by an elevation certificate completed by a licensed engineer, surveyor, or architect or by the community or the property owner.
[f] Personal communication with Don Beaton, Federal Emergency Management Agency, January 19, 2000.

SOURCE: Federal Emergency Management Agency, 1998a, 1998d.

As of September 30, 1998, more than 4.1 million policies had been written in the more than 19,000 communities participating in the NFIP. The total flood coverage exceeded $482.5 billion, generating a premium income topping $1.59 billion per year. Single-family residences account for more than two-thirds of all policies. Conservative estimates suggest there is an additional market in SFHAs of 4 million policies (Federal Emergency Management Agency, 1998b; Pasterick, 1998). Table 3.1 shows the total value of insured structures (coverage), number of policies written (earned exposures), average premium collected, and losses paid within the V-zone, the most hazardous coastal flood risk zone. Two percent of all NFIP policies are written for structures in the V-zone.

Originally, insurance subsidies were incorporated into the program as incentives for community participation and to encourage communities to pass floodplain ordinances that would affect new construction. Subsidies also were justified as means of preventing the abandonment of otherwise economically usable floodplains (Federal Emergency Management Agency, 1998d). Subsidized rates are approximately 38 percent of the full-risk premium needed to fund the long-term expectation for losses (Federal Insurance Administration, 1998a; Pasterick, 1998). As of 1999, the percentage of all insured structures requiring subsidized rates had declined to 30 percent. However in V-zones, roughly 70 percent of insured structures were built prior to 1981 and thus eligible for at least some subsidies. In 1999, FIA completed a study of the projected economic impacts of eliminating the subsidies altogether (as mandated by Section 578 of the NFIRA) (PricewaterhouseCoopers, 1999).

TABLE 3.1 National Flood Insurance Program V-zone Policies and Claims, 1986–1997 (unadjusted dollars)

	Pre-Firm 1986-1997	Post-FIRM, Pre-81 1986-1997	Post-FIRM, Post 10/81[a] 1986-1997	V-zone Totals 1986-1997
Earned premiums	$233,449,466	$38,382,894	$104,795,499	$376,627,839
Earned exposures	553,762	118,316	149,847	821,925
Average premium per policy	$422	$324	$699	$458
Expenses	$69,585,733	$12,450,393	$27,579,340	$109,615,466
Provision for losses	$163,863,713	$25,932,501	$77,216,159	$267,012,373
Actual losses incurred	$254,459,897	$38,382,894	$35,630,470	$328,473,260
Actual losses adjustment expenses	$6,744,821	$934,696	$1,039,938	$8,719,455
Total losses	$261,204,718	$39,317,590	$36,670,408	$337,192,715
Net income (deficit)	($97,341,004)	($13,385,089)	($40,545,751)	($70,180,341)
Percentage	-41.7%	-34.9%	38.7%	-18.6%

[a] Post-FIRM, Post10/81 structures are charged full-risk premiums for V-zones, including risk of damage from 3-foot breaking waves.

SOURCE: Federal Insurance Administration, 1998a

COASTAL EROSION AND THE NATIONAL FLOOD INSURANCE PROGRAM

Coastal flooding and erosion pose unique challenges for floodplain management and insurance programs. Unlike inland areas, many coastal areas are subject not only to inundation but also to wave attack and related velocity flows. Although the NFIP has taken steps to address coastal flooding and storm-induced erosion—such as the mapping of flood risk and increases in flood elevations for structures in consideration of wave height—it has not fully incorporated erosion into floodplain management and insurance rating schemes (nor was it required to under its enabling legislation). The risks of damage to structures from coastal flooding and erosion are summarized below. (A detailed description and quantitative analysis of coastal flooding and erosion damages can be found in Chapter 5.)

Coastal erosion and flooding are related processes that can increase the risk of damage to structures in the following ways:

- **Flood damage.** Waves and storm surge from a storm event of sufficient magnitude can destroy a house. Engineering studies by FEMA and the U.S. Army Corps of Engineers estimate that a wave 3 ft above the height of the first floor of a house will have sufficient force to cause damage equal to half the value of the house.

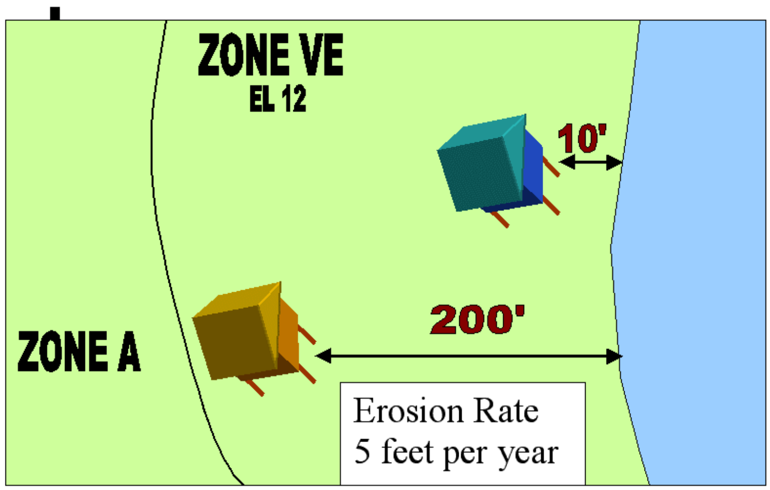
- **Direct erosion damage.** If a storm is of sufficient magnitude to erode the coastline to a position further inland, then houses in the way will be damaged. Some may be left standing, but they probably will not be habitable due to lack of utilities or might be condemned if they are on the beach or in public waters.

- **Higher wave heights.** Once the coastline has shifted inland, flood elevations for the same magnitude storm will be higher farther inland and thus can cause more damage.

- **Higher and more powerful waves in areas not previously subjected to high velocity waves.** Houses that were constructed in lower risk A-zones with less-stringent building codes may be subjected to waves of V-zone intensity as the shoreline moves inland.

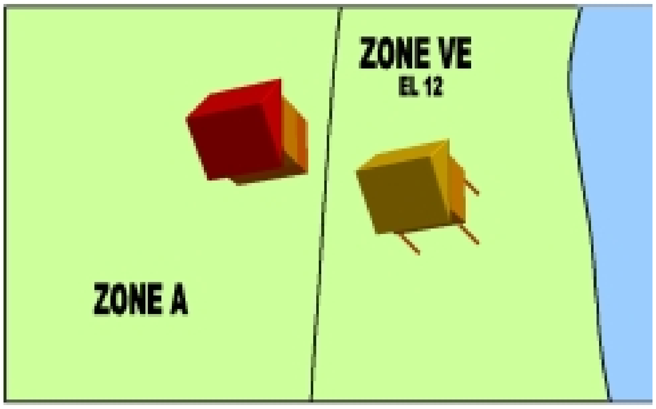
Erosion and erosion-related flooding are significant concerns for the NFIP's floodplain management and mitigation requirements and insurance premium structure. Erosion alters both the risk experienced over time by individuals building in erosion hazard areas and the changing loss potential for the NFIP as a whole. Thus, NFIP premiums and building requirements may not reflect the full risk of building on or near eroding shores. Thus, policyholders in the V-zone pay the same rate and are subject to identical building requirements regardless of the varying additional risk from coastal erosion (see Figure 3.2).

FIGURE 3.2 Though not reflected in NFIP premiums, erosion can increase the risk of damage. The two identical houses shown are both located within a V-zone in which the shore is eroding 5 feet (ft) per year. The house on the right is located 10 ft from the shoreline; the one on the left is 200 ft from the shoreline. Both houses are elevated to just above base flood elevation. The houses have identical insurance policies and premiums, even though the house closer to the shore is at a much greater risk of being damaged as a result of erosion or erosion-related flooding than the one located further back.

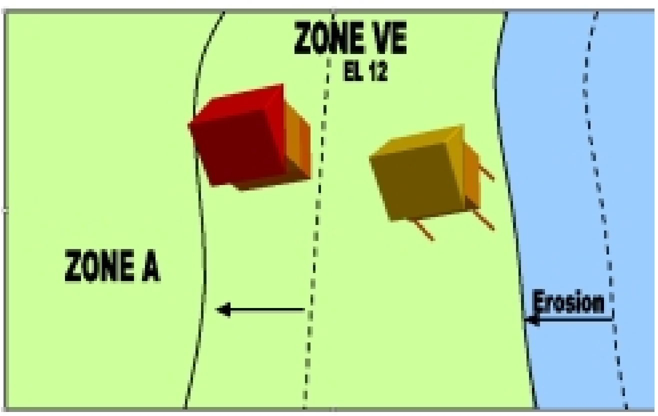


Erosion may also increase flood risks as the shore erodes inland. Structures originally built in compliance with NFIP standards eventually might migrate into riskier flood zones with more-stringent building requirements. Only by identifying areas subject to erosion and determining the rates of erosion can officials ensure that actuarial rates incorporate the changing risk as erosion proceeds, but even then risk zone changes may occur faster than flood studies can be updated and areas remapped. Even remapping in response to long-term gradual erosion does not always result in actuarial rates. For example, a structure originally built to compliance in an A-zone with a BFE of 13 ft might, after a period of erosion and subsequent remapping, be located within a V-zone with a BFE of 15 ft. As a result, it would now be at greater risk for damage from flooding and direct erosion. Figure 3.3 (a) and (b) illustrate the effect of erosion on the location of flood zone boundaries and exposure of structures to coastal flood hazards.

FIGURE 3.3 Erosion affects the location of flood zone boundaries and the exposure of structures to hazards.



(a) The two houses shown are both post-Flood Insurance Rate Map (FIRM) structures. The house on the right is located within the V-zone and hence required to be elevated on pilings. The other house, located in an A-zone, is not required to be elevated on pilings and instead is elevated on solid perimeter walls.



(b) Thirty years later, the beach has eroded and the FIRM for the area has been revised. Erosion has modified the hydrodynamics of the area and the V-zone has shifted landward so that the house on the left now is located in the V-zone. However, its owner still pays A-zone rates (because of grandfathering), and it is not built to V-zone standards. As a result, there is a much greater potential for damage or catastrophic failure.

However, because the Congress allows the "grandfathering" of existing policies, the owners of structures that change risk zones will continue to pay the same rates as before, even though the building is not built to V-zone standards and is no longer above the BFE. According to FEMA, "The contentious issue for the insurance component of the NFIP is whether new risk classifications (e.g., erosion zones) should be established so that the high costs associated with a subset of insureds subject to increased flood risk are not spread over a large group of insureds that may not be subject to the same degree of risk" (Crowell et al., 1999).

Prior to 1986, the costs of flood insurance studies, mapping, mitigation, loss payments, and other operations were covered by policy premiums and federal appropriations. From 1986 until June 1990, the cost of flood studies, mapping, mitigation costs and FEMA NFIP staff and related costs was funded through transfers of policyholder funds out of the National Flood Insurance Fund. Beginning in 1991, a federal policy fee was charged to each policyholder paid for mapping and mitigation. Since 1986, there have been no federal appropriations to pay any operating expenses. All expenses are covered by policyholders and statutory increases in borrowing authority; any money borrowed from the federal treasury is paid back with interest.

Incorporation of Erosion into the National Flood Insurance Program

Although the NFIP has not fully incorporated erosion into floodplain management and insurance rating methods, there are at least four ways in which erosion is considered indirectly through related program requirements and activities. They are: 1) consideration of vertical erosion in V-zone identification; 2) acceptance of storm-related coastal erosion losses as valid claims under the insurance coverage; 3) development of methods and guidelines for erosion mapping; and 4) periodic remapping of coastal flood zones and shoreline position. Each is discussed below.

V-zone Identification

Coastal processes are sufficiently different from fluvial processes occurring during flood events to deserve special attention. Since 1971, the NFIP has acknowledged the high risk of wave action to shoreline development (*Federal Register*, Volume 64, p. 42632 [1999])[8], and, since October of that year, it has required all development to occur landward of the mean high tide line. In 1981, FEMA recognized and adopted a methodology that incorporated wave run-up in the determination of BFEs and the landward extent of V-zones (Bellomo, et al., 1999).

In 1986, FEMA again reevaluated V-zone evaluation methods and, in 1987, began considering the effects of storm-induced dune erosion in the identification and mapping of these zones. Currently, the landward limit of the V-zone is defined as the most landward of the following three points:

1. the point where a 3-ft high wave might occur during a storm with a 1 percent chance of annual occurrence;

[8] Henceforth, references to the *Federal Register* will be abbreviated using the format 64 Fed. Reg. 42632 (1999).

2. the point where the eroded profile (or non-eroded ground profile, if applicable) is 3 ft below the computed wave run-up elevation during a flood event with a 1 percent chance of annual occurrence; or

3. the inland limit of the primary frontal dune.

The agency also began to develop performance-based criteria for evaluating shore protection measures in light of changes in flood hazard areas over time.

Insurance Coverage

Prior to the passage of the 1973 Flood Disaster Protection Act (P.L. 93-234), the NFIP paid claims involving erosion when a flood was determined to be the cause of the loss, even though the National Flood Insurance Act of 1968 did not contain any language regarding erosion. The 1973 Act formalized this approach by requiring coverage for damages resulting from “erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels….” Thus, FEMA explicitly began recognizing flood-related erosion damages to structures along the coast. This was a direct response to the recognition of cyclical lake level changes and corresponding changes in erosion patterns along the shores of the Great Lakes.

Insurance coverage is restricted to the principal structure and its contents. Damage to unattached structures (e.g., walkways, stairs, gazebos) and loss of land are not covered. Also not covered are “imminent” losses–cases in which structural damage has not yet occurred but may within the next few years because of gradual or storm-induced erosion. Imminent losses were addressed, however, by the Upton-Jones program from 1988 until the program ended in 1994 (Crowell, 1997).

Damage from erosion unrelated to flooding (as defined in Box 3.2) is considered under the NFIP to have resulted from “normal erosion” and is supposed to be denied coverage. Despite this, erosion is covered in low-lying areas (as shown in Chapter 6), although coverage is limited on bluffs. However, current insurance rates do not reflect the variation in risk among policyholders. Homeowners in erosion-prone areas are paying the same amount for flood insurance as are policyholders in non-eroding areas.

Erosion Mapping

The need to map erosion hazards—whether storm-related or gradual—has been recognized since the inception of the NFIP. In the mid-1970s, federal agencies began working with various regional councils and agencies to map erosion hazards (e.g., along the Great Lakes, Chesapeake Bay), and a number of states—New Jersey, Michigan, Virginia, Maryland, North Carolina, Washington, and others—initiated their own shoreline mapping programs (National Oceanic and Atmospheric Administration, 1976). However, no such areas have been designated on FIRMs, in part because FEMA has interpreted sections 1360 and 1370 of the NFIA as explicitly excluding damage from "normal" erosion (i.e., gradual erosion not related to flood events) as a covered risk.

In 1989, FEMA initiated the development of guidelines and specifications for erosion studies to promote consistency across the country in the determination of long-term erosion rates and in the identification of areas subject to erosion. After several years of research and preparation, this nearly completed effort was shelved because legislation mandating the mapping of erosion hazard areas was not enacted.

BOX 3.2 Definition of a "Flood" as Used in the National Flood Insurance Program

The *Code of Federal Regulations*, Title 44, Section 59.1, defines a flood as
(a) A general and temporary condition of partial or complete inundation of normally dry land areas from

(1) the overflow of inland or tidal waters;
(2) the unusual and rapid runoff of surface waters from any source; or
(3) mudslides (i.e., mudflow) which are proximately caused by flooding as defined in paragraph
(a)(2) of this definition and are akin to a river of liquid and flowing mud on the surfaces of normally dry land areas, as when earth is carried by a current of water and deposited along a path of the current.

(b) The collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as a flash flood or an abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding as defined in paragraph (a)(1) of this definition.

Remapping of Shorelines and Flood Zones

Periodic remapping of flood zones provides a pragmatic mechanism to account for changes in shoreline position retrospectively, as erosion proceeds. As of 1994, every community is supposed to be reviewed at least once every 5 years to determine whether map revisions are necessary. Currently, 63 percent of FEMA's maps are 10 or more years old, and 18,465 map panels (out of approximately 100,000) need hydrologic/hydraulic restudies and remapping (Federal Emergency Management Agency, 1999d). However, communities' existing FIRMs are frequently amended or revised through Letter of Map Amendments (indicating that a property either does not fall within the SFHA or is elevated above the BFE) or Letter of Map Revisions (which apply when portions of the map have been revised because of changes in flood risk zones, floodplain boundary delineations, map features, or BFEs). These methods are cheaper than updating an entire FIRM.

Policy Reform Proposals and Recent Developments

Efforts to address coastal erosion are continuing within FEMA, the NFIP, and the Congress. A keystone in reform efforts of the 1990s was the report *Managing Coastal Erosion* (National Research Council, 1990), which recommended that an erosion element of the NFIP incorporate the following objectives:

- transfer economic costs of erosion losses from all federal taxpayers to the property owners at risk by charging premiums that approximate the risks of loss;
- discourage inappropriate development from occurring in erosion zones as delineated by FEMA or the states; and
- promote the improvement of development and redevelopment practices in erosion-prone areas.

In 1991, bills were introduced in the House of Representatives and Senate (the National Flood Insurance, Mitigation and Erosion Management Act, H.R. 1236 and S. 1650) that adopted many of the NRC report's recommendations. They included provisions to establish 10-, 30-, and 60-year setbacks and incorporate the erosion hazard into the insurance premium, prohibit new construction of structures consisting of one to four dwelling units seaward of the 30-year setback line, and new construction of large structures seaward of the 60-year setback line. The bills also set mitigation requirements, limited insurance availability in the various setback zones, and required FEMA to establish land management and land use standards to guide construction away from high erosion hazard areas (U.S. House of Representatives, Committee on Banking, Finance and Urban Affairs, 1991).

The House bill passed by a wide margin (388 to 18), but the Senate bill failed to pass (U.S. Senate, 1992). Many groups strongly opposed the components of the legislation that would have incorporated land-use regulations for eroding areas into the floodplain management requirements of the NFIP. These provisions would have denied insurance to owners of existing property located in a "zone of imminent collapse" if they did not relocate or demolish their property within two years of the program's implementation. New construction, or substantial improvements, would have been prohibited within eroding areas.

The NFIRA of 1994 strengthened the mandatory purchase requirements of the 1973 Flood Disaster Relief Act by penalizing federally backed lenders if they failed to disclose and enforce the flood insurance requirement over the entire life of a loan, not just at its inception (U.S. House of Representatives, Committee on

Banking, Finance and Urban Affairs, 1994). As a result, there has been a substantial increase in the number of NFIP policies purchased. Flood insurance also can be forced on borrowers who are required to purchase flood insurance but fail to do so (Pasterick, 1998). The 1994 bill originally contained a provision that would have allowed the program to charge for the erosion hazard and impose setback requirements on erosion-prone properties. This provision, however, was removed from the final version. Other provisions of NFIRA that may directly impact the NFIP are:

- The Standard Hazard Determination Form
- Codification of the Community Rating System
- Establishment of the Flood Mitigation Assistance Program
- Authorization of Increased Cost of Compliance insurance coverage
- Mandating a five-year map update review
- Establishment of the Technical Mapping Advisory Council.

In 1995, the Congress proposed the Natural Hazards Protection Act (H.R. 1856 and S. 1043), which introduced the concept of multi natural hazard insurance. The Act was not passed, however, because it lacked land-use regulations and would have undermined the NFIP (Natural Hazards Observer, 1994, 1995a, 1995b). However, the multi-hazard concept is gaining prominence, as evidenced in an effort by FEMA, in cooperation with the National Institute for Building Sciences (NIBS), to develop a natural hazard loss estimation methodology called HAZUS which stands for Hazards U.S. (Barbara Schauer, National Institute of Building Sciences, personal communication, Jan. 7, 1999). A standardized, nationally applicable methodology has been developed for estimating earthquake losses. In 2002, previews of similar methodologies and models for riverine flooding and hurricane winds will be released to communities participating in FEMA's Project Impact Program. This tool will compute basic estimates of potential damage to residential, commercial, and industrial buildings, including direct economic losses and shelter requirements (National Institute of Building Sciences, 1999). These and similar loss potential assessment tools form essential elements of FEMA's multi-hazard National Mitigation Strategy, launched in 1996 (Federal Emergency Management Agency, 1996).

Recently, FIA Administrator Jo Ann Howard initiated a public review of the NFIP, soliciting input through the *Federal Register* in September 1998 (Federal Emergency Management Agency, 1998c). Interest groups such as the Association of State Floodplain Managers—members of which are the state and local partners of the NFIP—have provided significant input during this appraisal process (Miller, 1998). The comments received, some of them specifically on the coastal erosion issue, are to be summarized in a report by FEMA in 2000 (Federal Emergency Management Agency, 1998b).

Coastal Hazards Mitigation

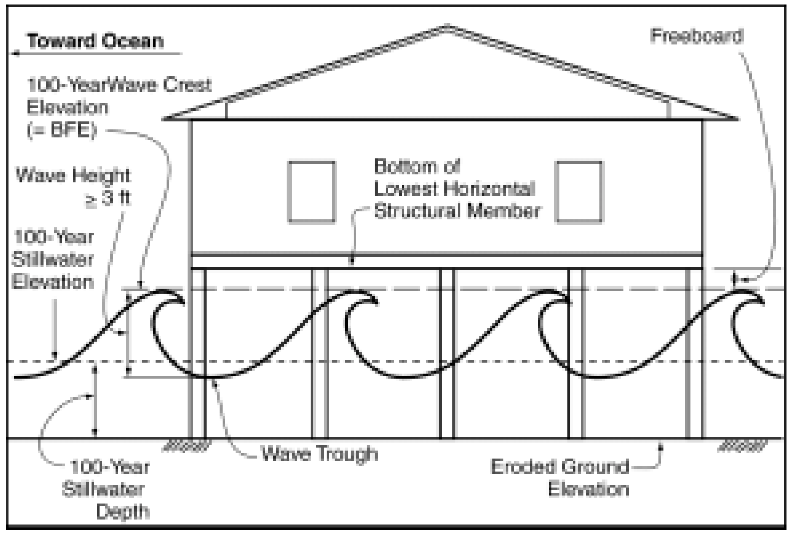
As part of the ongoing effort to lessen the impacts of disasters on people and property, the NFIP requires participating communities to adopt and enforce floodplain management regulations and minimum mitigation measures that either meet or exceed minimum criteria established by FEMA. The building and development standards developed by FEMA serve as minimum requirements for local ordinances. They require, for example, that residential buildings be elevated to or above the BFE. Nonresidential buildings can be either elevated or flood-proofed (i.e., made watertight) to that elevation. All buildings located in coastal high hazard areas (V-zones) are subject to additional requirements to help them withstand wave impacts. Figure 3.4(a) and Figure 3.4(b) provide examples of V- and A-zone construction, respectively, incorporating NFIP building requirements.

Communities also can obtain assistance from FEMA in adopting and enforcing compliant floodplain management ordinances and coastal construction practices. The agency is currently publishing its revised *Coastal Construction Manual*, which provides guidance on constructing buildings that are resistant to flood damages. Like HAZUS, the revised manual will address wind and seismic hazards, but will also include a detailed discussion of siting issues in coastal high hazard and erosion-prone areas.

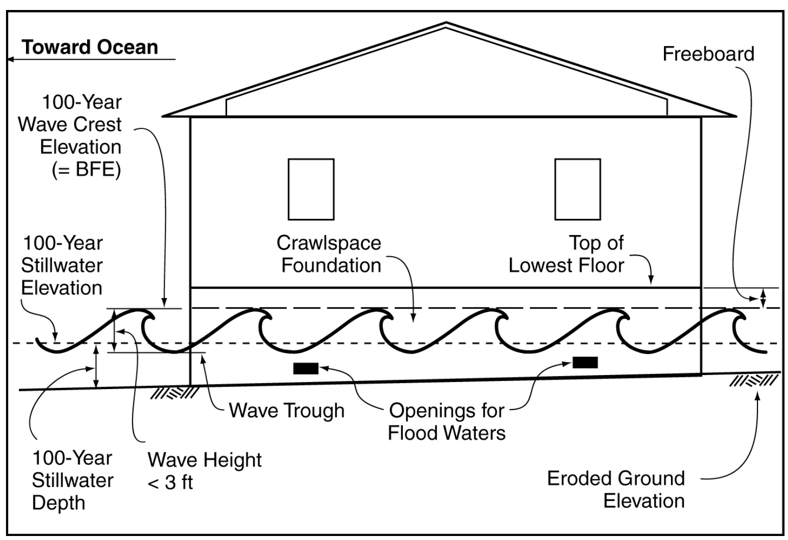
Reviews of mitigation standards in the different flood zones and experience with pre- and post-FIRM structures during severe coastal storms have shown that construction standards in the most hazardous areas (V-zones) are effective. Elevated houses built to code (especially those elevated on adequately anchored columns or piles) can withstand storm winds, wave attack, and scour for a time and can remain standing, even over open water. However, because of septic system loss or other utility failures, they may be condemned by local or state authorities and become uninhabitable (see Figure 3.5) (Rogers, 1986; Davison, 1993; Platt, 1998). Other difficult questions—regarding property rights, the threat of building collapse and public safety, demolition timing and financing, and maintenance of utilities and infrastructure supporting these structures—arise in such situations and are likely to become increasingly prominent in the future. Thus, the NFIP's structural mitigation requirements have resulted in fortified upward construction, but they have not ensured that buildings are located landward of erosion-prone areas.

FIGURE 3.4 The National Flood Insurance Program establishes building requirements for structures in the areas at greatest risk. V-zone building requirements are depicted in (a), and A-zone building requirements are shown in (b).

(a) V-zone building requirements



(b) A-zone building requirements



SOURCE: Federal Emergency Management Agency (in press).

FIGURE 3.5 Pilings protect this house from storm waves at Westhampton Beach, New York, but the loss of land renders it uninhabitable.

(Photo by Stephen P. Leatherman, 1993)

The Community Rating System (CRS), codified in the NFIP by the 1994 National Flood Insurance Reform Act, recognizes mitigation activities in four categories (public information; mapping and regulations; flood damage reduction; and flood preparedness) that communities can implement to reduce their flood insurance premiums (Federal Emergency Management Agency, 1999a). Erosion management activities are also recognized. Each activity is worth a certain number of credit points, and communities are rated on a 1 to 10 classification scale, 1 being the highest. Communities located in Special Flood Hazard Areas (SFHAs) receive a 5 percent premium reduction per class, up to 45 percent (class 1). Communities located outside of the SFHA zones are limited to a 5% discount no matter how many activities they adopt (Federal Emergency Management Agency, 1999b).

Although communities can get a modest credit for floodplain management, overall participation in the CRS program is low and the credits that are given are usually small. Only a few communities receive premium reductions of 20% or greater; most receive a 5 to 10 percent decrease. One reason why the CRS hasn't been widely adopted is partly because the mitigation actions and cumbersome participation procedures must be undertaken by communities, whereas the incentives for participation go to individual policyholders (Miller, 1998, see Issue 9). The 1,004 communities that do participate account for about two-thirds of the flood insurance policyholders covered by the NFIP.

Developed in 1997, FEMA's Project Impact: Building Disaster Resistant Communities is a nationwide initiative that focuses on forming public and private partnerships to provide local communities, homeowners, and businesses with disaster prevention tools. At the time of writing, there were nearly 200 communities participating in Project Impact and over 1,100 business partners. For more information on this ongoing project, see http://www.fema.gov/impact.

A final method of mitigating against flood and erosion losses is to relocate buildings away from flood- and erosion-prone locations. The NFIP has pursued several policies to implement the relocation option. First, the NFIP standard flood insurance policy, unlike the standard homeowner's insurance policy, does not require the insured to repair the building on the same premises to qualify for loss settlement on a replacement cost basis. This provision was intended to provide a financial incentive to the insured to relocate and either repair a substantially damaged or rebuild a totally damaged building at the new location. Second, Section 1362 (Flood Damaged Property Acquisition Program) of the NFIA, authorized in 1968, enabled the FIA to purchase buildings that were substantially or repetitively damaged from willing owners if the community agreed to accept the title and maintain the land for open space. This option was rescinded in 1994 by the National Flood Insurance Reform Act and replaced with the Flood Mitigation Assistance Program. Third, the Upton-Jones Program, an amendment to the NFIP signed into law on February 5, 1988, was available until the NFIRA in 1994 (see Box 3.3). The Upton-Jones Program paid homeowners up to 40 percent of the value of their house to cover the cost of relocating outside erosion hazard areas.

BOX 3.3 The Upton-Jones Program

The Upton-Jones Program—a direct response to claims denial problems along the Great Lakes coasts (Reilly, 1993)—was the federal government's initial effort to reduce the risk of erosion-related losses specifically. It authorized the payment of building demolition and relocation benefits (including septic system removal) to a flood insurance policyholder whose building was endangered by imminent collapse or subsidence as a result of erosion caused by a body of water. With the Upton-Jones amendment, claims could be paid at the request of the policyholder for buildings that had not yet experienced any damage. For the relocation option, policyholders could "receive up to 40% of the value of the structure, with the requirement that the structure be relocated landward of the 30- or 60-year setback line" (Crowell et al., 1999). For the demolition option, they could "receive up to 100% of the value of the structure, plus up to 10% of the value of the structure to pay for demolition expenses" (Crowell et al., 1999). The benefit covered only the value of the structure, not the value of land or any infrastructure. No additional premium was charged for this benefit, and no state or community erosion management was required as a quid pro quo for the subsidy. The Upton-Jones Program was an attempt by the U.S. Congress to identify those structures most at risk from erosion and storms and encourage action to reduce losses prior to their total destruction (National Research Council, 1990). Claims under the Upton-Jones Program are shown below.

Upton-Jones Program Claims

Applications	Claims	Expenditures	Average Claim
Total	922	$35 million	$60,000
Approved	581	$35 million	--
Denied	227	--	--
Withdrawn	65	--	--
Pending	49	--	--
Option chosen			
Demolition	73%	--	$68,000
Relocation	27%	--	$36,000
Claim location			
Coastal	87%	$32 million	$62,000
Riverine	13%	$3 million	$43,000

SOURCE: Crowell et al., 1999.

The Upton-Jones Program was suspended by the Congress in 1994 because of geographically limited usage; lack of community erosion management requirements; and negative, unintended outcomes. For example, property owners tended to "stick it out" in eroding coastal locations as long as possible, claiming insurance payments until a building was threatened inescapably by collapse. They also showed great reluctance to give up rental property while it still generated income. At the time of desertion, they then used the demolition option (receiving up to 110 percent of the building value) rather than the relocation option (up to 40 percent of the building value). Thus, the amendment actually increased the NFIP's costs, contrary to its own philosophy. In addition, Upton-Jones did not prevent communities from redeveloping the cleared lots; however owners could still obtain insurance coverage for the redeveloped structure if they met the setback requirements on the redeveloped lot.

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4.

CURRENT APPROACHES TO EROSION MANAGEMENT

A variety of approaches are used to cope with the increasingly challenging problem of coastal erosion and reduce the hazard it poses to humans, their property, and recreational and aesthetic values. The National Flood Insurance Program (NFIP), described in Chapter 3, is one of the primary approaches used at the federal level. This chapter describes coastal erosion management strategies and measures other than the NFIP available at all levels of government and to individuals. Each approach is evaluated based on the frequency of use, accumulated experience, obstacles encountered, costs, and effectiveness.

It is important to consider these responses to coastal erosion apart from the NFIP, for several reasons. First, floodplain management is an integral component of any loss reduction strategy. Second, responses to erosion, depending on their effectiveness, can either increase or reduce flood losses. Third, policy changes to the NFIP that affect eroding areas may induce certain responses by communities. The intent is usually to reduce erosion-related losses of shorefront property, including land, structures, infrastructure, and amenities (e.g., decks and gazebos), but these responses can change significantly the physical and economic nature of coastal development and potentially increase costs in other federal programs.

Although erosion affects every state with a shoreline, there is no comprehensive federal approach to managing coastal erosion per se, indirect benefits of the NFIP notwithstanding. Rather, erosion is addressed in a piecemeal manner by multiple agencies and levels of government. Similarly, groups of private citizens or individuals increasingly are involved in erosion control, but they do not always act in a concerted, mutually beneficial fashion. On retreating Gulf of Mexico and Atlantic coasts, some activities intended to stabilize the shoreline (e.g., groins, seawalls, and breakwaters) not only have been ineffective but have exacerbated erosion hazards locally. There are numerous examples of shoreline engineering structures that have caused beach loss or increased erosion on adjacent shores by modifying sediment supply or changing wave refraction patterns (Bush et al., 1996; Dean, 1999).

Regardless of their effectiveness, responses to coastal erosion are motivated strongly by the interests of property owners and coastal communities in protecting valuable shorefront property. In densely developed areas, such as Ocean City, Maryland, or Miami Beach, Florida, economists have judged beach nourishment to be worth the cost for the foreseeable future (Parsons and Powell, 1998). In other areas, groins, seawalls, bulkheads, and other measures are used to prevent erosion of the coastline, often at substantial individual or community expense. State-level responses to erosion range from doing nothing to restricting the use of hard structures and enforcing erosion-rate based setbacks (e.g., North Carolina), to providing no-interest loans and grants to stabilize the shoreline through cliff-hardening (e.g., the Maryland side of the Chesapeake Bay). An overview of these and other basic approaches available to individuals, communities, states, and the federal government is provided in the following sections.

APPROACHES AVAILABLE TO INDIVIDUALS

Individuals living on the coast usually do not start worrying about erosion until their property or home is visibly threatened. At that point, their choices are more constrained than they would have been if coastal processes had been considered prior to building or buying the land and structure. To have access to the maximal range of options, individuals need to be informed of erosion and flooding risks as early and often as possible. The approaches available to individuals are constrained by three factors: local and state rules and regulations (including building standards) that pertain to land use and development in shoreline areas, an individual's economic wherewithal, and the information and knowledge possessed by that individual regarding the erosion hazard and adjustment options. Typically, an individual learns about legal constraints and technical feasibility from municipal building inspectors, planners, code enforcement officers, or hired technical consultants and coastal engineers. To the extent allowed by local and state codes and personal financial means, homeowners can implement measures to reduce the erosion hazard when a structure is first built, redeveloped, or threatened by erosion.

Erosion prevention or delaying measures include maximizing the distance between the shoreline and oceanfront side of a structure by building as close to the inland property line as possible. Given the average life of a building (70 years), the safest approach available to individuals in eroding areas is to avoid the risk of erosion damage by setting the structures as far back as possible from the shore. In order to be avoid damage effectively, setbacks must be loose enough to avoid long-term erosion risks over the anticipated life of the structure. As coastal geologist and engineer Spencer Rogers points out, "a low standard such as a 30-year setback may delay, but does not eliminate, the long-term erosion problem" (Sea Grant Media Center, 1999). Moreover, because dunes provide the most important natural defense against storm surge and coastal flooding by buffering wave energy and serving as sand reserves, individuals can attempt to preserve, rebuild, or stabilize them after construction by using relatively inexpensive sand fencing and dune planting (see Figure 4.1).

FIGURE 4.1 Sand fencing (shown here in Southampton, N.Y.) encourages dune growth and revegetation. It is an inexpensive way to mitigate against future storm damage with soft structural means.

(Photo by Susanne C. Moser, October 1998)

Individuals also can reduce flood damages by complying with common flood mitigation standards, which include the construction of sturdy building foundations or elevation of the structure on strong, deeply driven pilings able to withstand considerable wave attack and flood-related scour. Although the initial costs may discourage the use of such measures, they are generally cost-effective when considering the reduced loss potential over the life of the structure (Federal Emergency Management Agency, 1997). The Building Performance Assessment Team (BPAT) program run by the Federal Emergency Management

Agency (FEMA) has shown that improvements in construction codes and standards, designs, methods, and materials used for both new construction and post-disaster repair and recovery have increased the damage resistance of structures to floods and therefore reduced costs to the NFIP (Federal Emergency Management Agency, 1999). However, fortifying structures in this manner may not reduce losses caused by horizontal erosion of the shore, because no protection is provided against the loss of land. Although houses may remain standing, they can be rendered uninhabitable by the loss of utilities or failure of the septic system.

To the extent that regulations allow, property owners also can build protective structures parallel to the shore in front of their properties. These structures can be hard—in the form of wooden, vinyl, or steel bulkheads; stone revetments; or bluff-stabilizing structures—or semi-hard (and usually temporary), such as sandbags of varying sizes or geotubes. For high-energy and open-coast environments, steel bulkheads are more effective than short-lived wooden or vinyl structures. However, strong storm waves can still overwhelm the protective structure and cause damage to the buildings behind it (see Figure 4.2). Bulkheads and seawalls cost $150–$4,000 per foot (ft) and dikes or levees cost $150–$800/ft, depending on engineering and construction specifications, design standards, construction materials, and geologic characteristics (Yohe et al., 1996). In some communities, small structures (e.g., groins) have been built perpendicular to the shore to intercept some of the sand transported with the littoral drift.

Many scientists argue that the construction of hard structures along eroding shores eventually leads to beach loss (Tait and Griggs, 1990). Although helpful in preventing damage to the immediate house and structure, such measures can accelerate erosion on neighboring properties, lead to the loss of the beach's natural capability to protect against storms, produce unsightly oceanfront areas when the structures become exposed, and have serious economic impacts on the larger community if the beach is lost (see Figure 4.3).

In locations where hard structures are not allowed, individuals may be allowed to alter the grade of a retreating bluff or beach scarp or maintain a protective dune line in front of their properties through sand fencing. Individuals also may be able to obtain permits for beach scraping to pile sand mounds in front of their properties. Beach scraping is allowed in South Carolina and Texas, for example, and is being reintroduced on the south shore of Long Island, N.Y. (e.g., Village of Quogue). On retreating shorelines, these measures are at best temporary, although they can help minimize flooding during a storm. Other measures for managing erosion differ in the degree to which they interfere with sediment transport processes. In some cases, local regulations may allow individuals to use organic material, such as old Christmas trees, hay bales, or branches, to reduce the impact of wave attack on their property (see Figure 4.4). Although these materials are readily available and cost little or nothing (e.g., a bale of hay cost approximately $70 in Texas in 1999), they do not reliably protect shoreline areas from coastal storms or waves over the long term, and many beach residents and visitors find them unsightly when exposed.

If a parcel of land is deep enough, then an individual may choose to relocate a house farther inland, an option that can be more cost-effective, even in the short term, than hard-engineered structures. For instance, the cost of moving a single-family house in North Carolina is between $10,000 and $15,000, excluding the driving of pilings at the new location. In Caplen, Texas, owners moved their homes back from the eroding bluff at a cost of $25,000 per 1,200-$ft^2$ home (Burrus, 1999) (see Figure 4.5). Relocation is technically feasible in most cases, but shallow lot size or a lack of comparable lots further inland is frequently a limiting factor. In addition, lots further inland are less valuable than are those closer to water, so property owners often prefer not to relocate because it would reduce their rental income. This economic incentive encourages owners to keep their oceanfront property as long as possible.

FIGURE 4.2 This bulkhead in Scituate, Massachusetts did not prevent damage to the houses from powerful storm waves that overtopped the structure during a winter storm.

(Photo by Stephen P. Leatherman, February 1978)

FIGURE 4.3 A groin field at Westhampton Beach, N.Y., has created an "erosion hot spot" downdrift.

(Photo by Stephen P. Leatherman, 1993)

FIGURE 4.4 Hay bales are used as the core of artificial dunes on Galveston Island, Texas. Hay bales are an inexpensive means of rebuilding dunes and encouraging the regrowth of dune vegetation, but they are limited in long-term effectiveness and unsightly when exposed.

(Photo by Susanne C. Moser, February 1999)

FIGURE 4.5 This single-family home in Caplen, Texas, which has 1,440 square feet of living space, was relocated at a cost exceeding $20,000.

(Photo by The Heinz Center, October 1998)

Many states and communities require individuals to exhaust all retreat options before attempting structural shoreline protection. Government funds (local, state, and federal) may be available to defray some of the relocation or mitigation costs. If relocation within a lot is not possible, then municipalities or other public institutions may buy out a property owner and offer a property of comparable value farther inland in exchange, thus possibly averting several problems that tend to arise in eroding areas, including a loss of beach, hardening of the shoreline, and legal "takings" challenges by property owners. In addition, private individuals can choose to protect their coastal properties from future development by either donating or selling them at a discount to a government or private conservation agency, or using conservation easements (Dean, 1999).

Individuals also can choose to purchase flood insurance to spread the risk of loss. Federally backed flood insurance, reviewed in Chapter 3, covers storm-related erosion damages to structures but not to the land. Flood insurance reduces the economic consequences of storm-induced flood and erosion losses at relatively low expense, but, unless combined with mitigation actions, does not reduce overall damages.

Lastly, private individuals or property owners along a stretch of eroding oceanfront may organize into groups (e.g., homeowners' associations) to pursue a common approach to the erosion problem and generate the funds necessary to finance neighborhood-wide beach nourishment or more expensive projects, including the acquisition of land, that may be out of reach for a single individual. Within the constraints of local regulations, these nongovernmental associations may choose to lobby local governments for increased beach management efforts or self-impose a tax to finance such projects. For example, shorefront property owners on Bogue Island, North Carolina, initiated self-taxation for beach nourishment, prompting the municipal government to participate in, and contribute financially to, a wider beach management effort. In Santa Barbara, California, residents moved quickly when a 69-acre parcel of coastline—the last piece of undeveloped coastline in town, and one used by many residents—came up for sale. The community raised $3.5 million from the county government and individuals to purchase the land (Dean, 1999). The conservation of this beach has created a recreation area and an erosion buffer zone for this community.

Table 4.1 summarizes the approaches available to individuals for coping with coastal erosion. To reiterate, these approaches are constrained and guided by the regulations and policies devised by governments. Individuals cannot regulate one another's activities, impose land-use plans, provide incentive programs, or do public outreach.

TABLE 4.1 Summary of Erosion Management Approaches Available to Individuals

Intervention	Response measure	Basis and Constraints
Pre-construction	Setbacks; building behind frontal dunes; location according to applicable zoning, subdivision, and planning ordinances	Local/state regulations include location restrictions
(Re-) Construction, structural mitigation	Modify building design (foundation, deep pilings, etc.)	Building code regulations provide minimum construction standards
Property protection	Dune restoration, fencing; buffering against wave attack with organic materials	Local/state regulations require/allow protection
Shoreline alteration	Sand scraping, sandbags, beach/bluff grade change, bulkheads, revetments, small groins, bluff-stabilizing structures	Local/state/federal regulations allow/limit shore alterations
Loss reduction	Relocation of building, insurance coverage for storm-related flood and erosion damages; hazard information gathering	Local/state/federal regulations and policies offer assistance and insurance

APPROACHES AVAILABLE TO COMMUNITIES

Communities or local governments address coastal erosion problems by developing and enforcing local ordinances to guide decisions on land use, zoning, subdivision practices, building standards, hazard mitigation, and management of public beach areas. Local ordinances typically vary as to whether they address erosion problems and shore protection on a case-by-case basis (i.e., property by property) or through a broader, community-wide approach. Communities often use both approaches. These ordinances may be either constrained or facilitated by programs and statutes at the state level. Local governments also may be empowered to implement state laws (e.g., coastal zone management statutes) and federal programs that relate to shoreline protection, hazard mitigation, or coastal management (e.g., the NFIP).

When communities use a case-by-case approach in dealing with erosion problems, the decisions dictate the choices available to individuals (discussed in the previous section). These decisions concern matters such as the implementation or enforcement of setbacks, building standards, or permits for shorefront protection of individual properties with soft- or hard-engineered structures (see Box 4.1). Local authorities also have the power to grant variances from local regulations or impose conditions on a permit application; this power frequently is exercised to mitigate the environmental impacts of development.

When communities use more comprehensive, community-wide approaches to erosion management, they have an opportunity to consider the cumulative impacts of shorefront development and protection measures and develop broader flood and erosion hazard mitigation programs. For example, they can use zoning ordinances to restrict certain types of development in the most hazardous areas (e.g., prohibiting the construction of buildings exceeding a threshold square footage or height, industrial complexes, or hazardous facilities along the immediate shorefront). Zoning ordinances also may affect subdivision practices and the types of infrastructure development allowed in shoreline areas.

To generate funds for community-wide projects such as the purchase of open space and beach nourishment, communities can use various taxation schemes. Several communities along the south shore of Long Island, for example, recently voted to establish a real estate transfer tax (exempting transfers below a certain exchange value to protect low-income populations) to pay for the preservation of open space. Other common local approaches to funding shoreline protection projects include beach user fees; hotel/motel occupancy taxes; and so-called impact fees, which generally are tied to development projects that cause some measurable, unmitigated impact on coastal resources.

BOX 4.1 Combating Erosion of Siasconset Beach on Nantucket Island

Long before the well-to-do began building summer camps on Siasconset ('Sconset) Beach in the early 1900s, Africans from the Portugese colony of Cape Verde lived for months at a time in fishing shacks lining the coast of Nantucket Island in Massachusetts. Fishermen by trade, they dried their daily catch of codfish and sold it throughout eastern Massachusetts. Eventually, some residents added living rooms and bedrooms to their shacks in what is now called Codfish Park. Since 1957, erosion has eaten away 4 to 7 feet (ft) of land per year on 'Sconset Beach. Several homes have been moved. Still others wash out during harsh winter storms, when the beach narrows to just a sliver (see Figure 4.6).

Those who think the ocean's march can be stopped find hope in a method discovered by accident at the Danish Geotechnical Institute. In 1999, the founder of the 'Sconset Beach Preservation Fund and dozens of residents persuaded the Nantucket Conservation Commission to approve the installation of wells, pipes, pumps, and a 2,200 stretch of 8 ft tall sand tubes in a desperate attempt to save their homes and nearby Sankaty Head Lighthouse. The theory is that, by lowering the water table, these measures will make the sand drier and more porous, allowing water carried by waves to percolate into the sand. As the water drains, it will deposit suspended sand onto the beach. Because less water will be rolling back from the beach into the sea, it will carry off less sand with the backwash. The newest plan calls for installing 18-ft-long, 8-ft-wide sand tubes into trenches along the base of the bluff to protect it. During winter storms, waves as high as 20 ft can tear away at the bluff, causing homes built there to tumble down. The geotextile tubes, or "sand sausages," will be covered by sand. One will stretch 1,600 ft and the other will be 600 ft long.

Some feel it is silly to try to protect a beach when the whole island has been eroding for centuries. "Nantucket is a sand bar that has been eroding for 3,000 years," observed one opponent of the effort. "The plan may work in the short term, but there's only one long-term solution: They're going to have to move."

SOURCE: Adapted from Rodriguez, 1999. See also Curtis and Davis,1997; Turner and Leatherman, 1997.

Figure 4.6 The front of this house on 'Sconset' Beach, Nantucket was torn away by storm waves.

(Photo by Stephen P. Leatherman, 1996)

Floodplain management ordinances typically address hazard mitigation on both a case-by-case and community-wide basis. Local governments, for instance, specify building requirements—implemented through individual building permits—in high-hazard areas as well as provisions that apply throughout the community (e.g., zoning, public outreach, education). Through the Community Rating System (a flood insurance rating and community inspection program discussed in Chapter 3), communities are encouraged to voluntarily take on approved activities that exceed the NFIP minimum hazard mitigation requirements; communities that do so are rewarded with reduced insurance rates. They can achieve better ratings by instituting community-wide measures such as erosion hazard mapping and regulation; data collection, maintenance of nonstructural programs designed to reduce the rate of erosion; and the preparation and adoption of erosion management plans that guide land-use development, redevelopment, post-disaster recovery, and mitigation decisions.

Local governments also are responsible for managing their public beaches and, thus, for protecting and restoring those areas in case of beach erosion. Because public funds are used to finance public beach management, local governments frequently encounter controversy over the appropriate levels and means of protection. In the past, communities frequently built hard structures, such as groins and seawalls. More recently, however, communities increasingly have chosen "soft" engineering solutions (e.g., beach scraping, dune stabilization, mangrove planting and maintenance) or sought ways to fund beach nourishment projects. They also engage in or request federal and state assistance with post-storm responses to erosion such as rebuilding dunes (see Figure 4.7) and beach nourishment. In cooperative shoreline management projects that involve several levels of government (e.g., projects supported by the U.S. Army Corps of Engineers [USACE]), communities or counties play vital roles as local sponsors.

FIGURE 4.7 After oceanfront homes at Kure Beach, North Carolina, were destroyed by Hurricane Fran, attempts were made in 1996 to rebuild dunes along the coast.

(Photo by Robert Willett, The News and Observer, 1996. Reprinted with permission of *The News and Observer Publishing Company*, Raleigh, N.C.)

In a survey of more than 400 coastal communities nationwide, Godschalk et al. (1989) determined the frequency of use of particular coastal hazard management measures in the late 1980s. Selected measures that are particularly relevant to erosion hazard management are shown in Table 4.2 which shows that some of the less effective management tools (e.g., measures ranked 10, 11, 12) are used more often than others, including the top-ranked approach. Godschalk et al. (1989) attribute this pattern largely to the political obstacles encountered in both the policy-making and implementation phases. Their research revealed that the most important hurdles to the enactment of such management measures include generally conservative attitudes toward government control of private property rights, a perception that communities can "weather the storm," inadequate financial resources, other local problems that are more pressing, and opposition from real estate and development interests (Godschalk et al., 1989).

An additional major constraint on community-wide coastal erosion management is a general lack of appropriate staff, resources, and technical expertise at the local government level. Local agencies seldom employ their own geology experts or coastal zone or floodplain managers. If, among all other local management challenges, the erosion problem assumes a priority status, then a community may be able (usually with financial and technical assistance from county and state governments) to commission an environmental impact statement (EIS) or other technical studies on the extent of, and management options for, the erosion problem. Such an environmental assessment was undertaken in 1997 in the Village of Quogue on Long Island, NY; it resulted in the establishment of a no-hardening rule along the community's oceanfront properties. More comprehensive assessments are under way in the town of Southampton, N.Y., and city of Ocean Shores, Washington, which are seeking to strengthen and clarify local codes on shoreline protection and develop long-term solutions to erosion problems (see Box 4.2 and Box 4.3). Such assessments are usually the important first step toward the development of a more comprehensive and systematic coastal erosion management scheme at the local level. Again, financial restrictions often limit even the compilation of a scientific and policy option assessment.

Within and across communities, nongovernmental institutions have developed and implemented creative efforts that combine recreation and education with important aspects of beach management. In Oregon, for instance, members of a coastwide environmental group are being asked to watch the progress of shoreline change at "erosion hot spots" (see Box 4.4). In Galveston, Texas, an independent school district developed a high school beach monitoring program, which not only provided students with hands-on learning opportunities but also furnished the city with useful data (see Box 4.5). In southern Maine, coastal residents are trained by state geologists to measure beach profiles and gather essential data for the development of beach management plans. Such projects are of great educational value, usually improve understanding of coastal processes, give insight into differing positions on shoreline protection, and ultimately can lead to greater buy-in and ownership of a chosen management option.

In many coastal areas, communities are beginning to develop regional, in-state shoreline management approaches that are organized around, for instance, a watershed, bay, or littoral cell. The shift to regional approaches, which frequently involve state and federal agencies, has resulted in part from a recognition and improved understanding of sediment transport processes and the downdrift impacts of individual communities' shoreline protection activities. Examples of such regional approaches can be found in southern Maine, Hawaii, Oregon, and southern Washington. The advantages include pooling of local resources; mutual education and fostering of understanding and collaborative ties; and increased political leverage with state and federal institutions that could provide legal, technical, or financial assistance (Moser, 1998).

TABLE 4.2 Selected Community Coastal Management Measures by Frequency of Use and Effectiveness

Effective-ness Rank[a]	Frequency of Use[b]		Type of Measure	Type of Response[c]
	#	%		
1	109	27	Special hazard area ordinance	Planning
2	152	38	Dune protection regulations	Regulatory
3	185	46	Locating public structures and building to reduce storm risk	Nonregulatory
4	216	54	Shoreline setback regulations	Regulatory
5	118	29	Acquisition of undeveloped land in hazardous areas	Public land ownership and direct land management
6	12	3	Acquisition of damaged structures in hazardous locations	Public land ownership and direct land management
7	84	21	Transfer of development potential from hazardous to non-hazardous sites	Nonregulatory
8	118	29	Locating capital facilities to reduce/ discourage development in hazardous areas	Nonregulatory
9	9	2	Building relocation program	Nonregulatory
10	354	88	Zoning ordinance	Regulatory
11	347	86	Subdivision ordinance	Planning
12	340	84	Comprehensive/land-use plan	Planning
13	103	26	Hazard disclosure requirements in real estate transactions	Nonregulatory
14	56	14	Acquisition of development rights or scenic easements	Public land ownership and direct land management

[a] This column shows how selected measures rank in relative effectiveness in reducing storm-related hazards, as perceived by the respondents to a community survey. The scale ranges from 1 to 14, with 1 being the most effective.

[b] A total of 403 communities are represented. The # column indicates the number of communities using a particular measure; the % column indicates the percentage of the total.

[c] Some measures may involve regulatory, planning, and nonregulatory aspects. The measures were categorized based on the primary modality of implementation.

SOURCE: Adapted from Godschalk et al. (1989)

BOX 4.2 Assessing Erosion Management Options for Southampton, Long Island

Those who have built on the shorefront of Southampton, New York, are no strangers to the hazards of living along a dynamic barrier beach or the problems of long-term erosion. So far, they have had to deal mostly with the seasonal fluctuations of the beach and occasional hurricane or severe Nor'easter, from which the beaches usually recover in the following calmer season. Long-term average erosion rates are on the order of 1.5 feet (ft) per year or less, with the exception of areas near structures that run perpendicular to the shore, which have increased erosion rates significantly by intercepting the littoral drift (Leatherman et al, 1999). In addition, the phenomenon of longshore sand waves—the periodic wave-like accumulation and downdrift movement of sediment with the littoral current—can produce temporary "erosion hot spots" (lasting 1 or more years) moving along the shore. With seasonal beach width fluctuations of up to 200 ft, these combined shoreline movements can produce significant threats to individual properties and structures.

Since 1988, the town of Southampton has administered New York's Coastal Erosion Hazard Area Act through a local ordinance. Although the town has encouraged both the elevation and relocation of structures back from the shoreline, it has permitted structural protection measures as long as they are located 25 ft landward of the landward toe of the dune or natural protective feature and meet certain minimum standards. Since the early 1990s—when Long Island experienced several severe winter storms from which the beaches did not entirely recover—numbers of applications for both emergency and non-emergency shoreline hardening structures have increased significantly.

Eventually, the town began recognizing the potentially negative impacts of hard structures on its most valuable resource—the beautiful beaches—and therefore began to favor nonstructural solutions to recurring erosion problems (see Figure 4.8). In response, the town denied several permits for bulkheads and other hardening structures. The subsequent political and legal fights among residents, the town, and the state led the town to initiate a general environmental impact study (GEIS) to assess the local erosion problem and the range and feasibility of management options over the short- and long-term. Still awaiting the final GEIS, state and local officials expect that the town will follow the example of one of its incorporated villages, Quogue, and establish a no-hardening rule for its shore, instead requiring the relocation of threatened structures back from the encroaching sea and/or soft protection measures. Given the generally deep lots along the oceanfront of Southampton, this option is feasible and cost-effective in most cases.

FIGURE 4.8
Erosion has uncovered the bulkheads intended to protect the houses behind a dune in Southampton, N.Y.

(Photo by Susanne C. Moser, October 1998)

BOX 4.3 Learning to Deal with a New Problem: Ocean Shores, Washington

For much of the latter half of this century, Washington State has experienced seasonally punctuated and locally confined "hot-spot erosion" along its open-ocean shoreline, especially on either side of jetties built by the U.S. Army Corps of Engineers to protect inlets and the entrances of harbors. More frequently, the state had to deal with the unpleasant side effects of too much sand: the obstruction of the ocean view by growing dunes; "drowning" of houses, roads and other infrastructure under sand; extension of access roads to the beach; and property rights issues around the newly created land. In the late 1970s, however, researchers noted that the shoreline accretion rates had begun to slow, and by the late 1980s, the trend seemed to have reversed. Erosion became more common, even if still confined to a number of hot spots. One of these erosion hot spots emerged north of the Grays Harbor jetty in the city of Ocean Shores.

Ocean Shores is a destination resort and retirement community of some 3,000 year-round residents, 10,000 part-time residents, and up to 60,000 visitors during peak summer weekends. The city awoke to the growing erosion threat in the early 1990s. For several years, erosion had eaten into the city's southern end, the prime location for the homes of new arrivals who wanted to live and retire in the county's fastest-growing coastal community. Erosion was perceived as a big problem after several severe winter storms began to threaten a $20–$30 million condominium complex as well as a significant portion of the city's infrastructure located behind the primary dune. Although both the state and city recognized shoreline protection, wave action, erosion, and flooding as coastal management challenges, neither was really prepared to confront the emerging crisis with an explicit and well thought out erosion management strategy, and neither had the necessary funds to implement such a strategy.

In a race against time, spurred by El Niño years with severe winter storms, a flurry of action was initiated to find an acceptable short-term and feasible long-term solution. The condo owners organized to privately fund, and more effectively lobby for, emergency protection of their investment. Subsequently, a two-tiered stone revetment (locally known as a wave-bumper) was permitted and built in front of the condos, albeit on the public beach. In addition, private consultants and several coastal communities lobbied the U.S. Congress and state legislature for funds to study and develop short-term and long-term management responses to the erosion problem. The governor convened a Task Force on Coastal Erosion to develop statewide recommendations, and coastal communities signed an inter-local agreement to coordinate lobbying and management efforts. Local and state agencies launched a major public education and awareness raising campaign through workshops, public meetings, the local press, and improved collaboration between local and state agencies.

In Ocean Shores, the city conducted a general environmental impact study (GEIS)—first with the help of consultants, then increasingly in collaboration with state agencies, the USACE, and the independent Battelle Memorial Institute—to determine the city's long-term management strategy. A strong effort was mounted to solicit public input through a Citizen's Involvement Committee as well as policy and technical advisory committees. As of October 1999, a final recommendation was pending upon the completion of the review period of the draft GEIS. An emergency geotube barrier was built to prevent the breaching of the primary dune – the thinning natural barrier protecting the city's infrastructure and properties at the south end of town.

BOX 4.4 Keeping an Eye on "Erosion Hot Spots" in Oregon

For 28 years, the Oregon Shores Conservation Coalition (OSCC)—an all-volunteer, nonprofit environmental advocacy group—has been keeping an eye on issues affecting the state's coast. It is also the only environmental group that gets involved in the politics of coastal erosion management in Oregon. In the coalition's early years, it actively fought to get coastal hazard and coastal land use goals into the state's land-use plan (Oregon Department of Land Conservation and Development, 1995); since then, the OSCC has watched how state and local communities are implementing the plan. Its members file legal complaints and submit testimony regarding permit decisions, work with local adopt-a-beach groups to assess how well Oregon is ensuring public access to the coast, and participate in research and stakeholder processes that deal with coastal hazards (Oregon Sea Grant, 1994). The coalition also helped create a land trust in central Oregon while entertaining a variety of other ongoing activities and programs.

One of these programs was initiated roughly 5 years ago by the OSCC (Fran Recht, President, Oregon Shores Conservation Coalition, personal communication to Susanne Moser, November 11, 1998). In this "Mile-by-Mile Coast Watch Program," volunteers (only some of whom are OSCC members) regularly observe what is happening along a particular stretch of the coast. Part of their job is to keep an eye on local erosion hot spots and what happens to them as the seasons change. The information gathered is channeled back to the OSCC, which uses it to formulate coastal conservation strategies, initiate political action, and raise awareness in local and state agencies and the broader population. Recht says the volunteers not only learn more about their coastal environment but also "develop a real sense of ownership for the stretch of coast they are watching," which may be the best guarantee of conservation of the extensive dunes, sandy pocket beaches, species-rich estuaries, and steep cliffs from which countless locals and visitors enjoy breathtaking views of the Pacific coastline.

BOX 4.5 Hands-on Learning About Coastal Change in Galveston, Texas: Research and Education Combined

In 1997, the Bureau of Economic Geology (BEG) at the University of Texas at Austin initiated an innovative collaboration with Ball High School, the city of Galveston's only public school. Geologists Roberto Cruteros and Jim Gibeaut of the BEG began to develop a hands-on beach monitoring class for Ball High sophomores, juniors, and seniors. What motivated the geologists was their own experience of working with state and local officials, who often failed to understand and appreciate coastal dynamics, seasonal shoreline variability, and long-term shoreline change. So the pair launched an enhanced science education program with more than $35,000 in funding and staff support from the newly established Texas Coastal Zone Management Program (Lutz, 1998). Several Texas oil companies contributed matching funds, hoping that someday these students might work for them and understanding that public education is a crucial ingredient in enhanced coastal stewardship.

The goal of the program is to teach students and teachers about coastal dynamics and help them to appreciate this highly dynamic environment. Participants learn how to measure topographic beach and dune profiles; monitor weather conditions, the state of the sea, and the rate of long-shore drift; identify dune vegetation; and analyze the collected data. They get a course in local geography, geology, botany, meteorology, math, and computer-based statistics all in one—an experience that fosters teamwork, communication skills, observation skills, and problem-solving strategies. Over the two years that BEG has been working with Ball High—a pilot project eventually to be expanded to other coastal Texas high schools—students have caught on quickly and "do a great job" (Jim Gibeaut, University of Texas at Austin, personal communication, February 8, 1999). With in-class theoretical training and practical guidance during the outdoor learning sessions, Ball High students are the first links in a beach monitoring network that eventually will span the Texas coast. The geologists are helping students develop a World Wide Web site on which their data and photographs will be posted. Eventually, Ball High students will be connected with students from other high schools who will learn to monitor beaches along their own stretches of the coast.

Although the project seems to require a lot of effort, Gibeaut asserts that every bit is worth it. He is certain that the project will be successful: Students learn about the local environment and geological principles, gain experience analyzing and interpreting data and performing field work, and acquire computer skills. They also have fun, even in the rain. And it helps to know that they are contributing to a real research project.

APPROACHES AVAILABLE AT THE STATE LEVEL

Since the passage of the 1972 Coastal Zone Management Act (CZMA) (P.L. 92-583), coastal states have been central players in the management of coastal resources and shorefront areas, acting as intermediaries between federal agencies and local governments and as active shapers of coastal policies at all levels. As summarized by a recently completed National Oceanic and Atmospheric Administration (NOAA) study of the effectiveness of state coastal zone management programs (henceforth referred to as the effectiveness study),

> State coastal programs have resulted in more attention to issues such as erosion, sea level rise, and cumulative adverse impacts resulting from development on receding beach and bluff shorelines and sensitive natural habitat areas. States (coastal management programs) have been at the forefront of addressing shoreline use conflicts such as the demand for shoreline armoring to protect existing upland structures to the detriment and loss of natural beach systems (Bernd-Cohen and Gordon, 1998).

A variety of physical, socioeconomic, historical, political, and institutional factors influence how the 30 coastal states and various territories have addressed their respective problems related to shoreline change. Some states (e.g., Oregon, California, Maine) have coastal zone management programs that predate the CZMA and thus were among the first to establish comprehensive, federally approved state programs. Others (e.g., Georgia, Texas, Ohio) historically engaged in more limited, piecemeal coastal land use and shoreline management but recently have strengthened their efforts and now participate in the federal Coastal Zone Management Program (CZMP). As of 1999, 32 of 35 coastal states and territories had developed programs under the CZMP, protecting more than 99 percent of the nation's oceanic and Great Lakes coastline (National Oceanic and Atmospheric Administration, 1998). Only Indiana, Minnesota, and Illinois do not participate in the CZMP (National Oceanic and Atmospheric Administration, 1999b). Although Minnesota does not participate in the CZMP, it does have a state shoreland management program begun in the late 1960's that sets standards for development along Lake Superior, including environmental setbacks.

Thus, the states differ widely in experience, institutional structure, and capacity for managing coastal erosion. These factors, together with legal and political constraints (e.g., state laws, attitudes, activism related to property rights; other overriding state management concerns), determine to a large extent which shoreline management policies are adopted by a state. Accordingly, states differ widely in their preferred approaches to coastal zone management and shoreline protection (Knecht et al., 1996).

The effectiveness study (Bernd-Cohen and Gordon, 1998) also examines the broad range of processes and tools used by states to protect resources in coastal shorefront areas. These processes and tools are grouped into four basic shoreline management approaches: regulatory measures and planning tools; direct land management, restoration, and acquisition; non-regulatory measures; and research, education and outreach. One-third of the coastal states have established specific beach, coastal erosion, or special (hazard) area management programs that use and combine any number of these processes and tools (National Research Council, 1990; Platt, et al. 1992a). The use of the five basic approaches by each coastal state and territory is summarized in Table 4.3 and described below.

Regulatory Measures

Regulatory measures for shoreline management prescribe specific rules and conditions for land use, construction, and development. These measures have to meet procedural and substantive due process requirements and be established by a legislative body or another authorized governmental agency. In general, they are implemented on a case-by-case basis through activity-specific permits to individuals (Buck, 1996). They usually include a determination of the inland extent to which any coastal regulations apply and name the state and local agencies authorized to administer the regulations. These measures also define the types of activity regulated and specify any restrictions (or exceptions) with respect to

- new construction or reconstruction of residential and commercial buildings through setbacks and control zones;
- construction or repair of shoreline stabilization structures;
- pedestrian and vehicular access or traffic in shorefront and dune areas; and
- use or alteration of dune and other shoreline habitat areas (Bernd-Cohen and Gordon, 1998).

TABLE 4.3 Coastal Zone Management Tools Used by States[a] and Territories[b] to Protect Beaches, Dunes, and Bluffs

Tools	AK	AL	AS	CA	CT	DE	FL	GU	HI	LA	MA	MD	ME	MI	MP	MS	NC	NH	NJ	NY	OR	PA	PR	RI	SC	VA	VI	WA	WI	all
Regulatory tools and plans = 10																														
Restrict construct.	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*		*	*	*	*	*	*	*	27
Setbacks		*	*	*		*	*	*	*			*	*	*	*	1	*	*	*	*	*	2	*	*	*	*	*	*	*	23
Control areas	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	*	*	*	*	*	2	*	*	*	*	*	*	*	27
Restrict armoring		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	28
Restrict access	*	*		*	*	*	*	*	*		*	*	*	*	*	*	*		*	*	*			*	*	*		*	*	23
Protect habitat	*		*	*	*	*	*	*	*		*	*	*	*		*	*	*	*	*	*		*	*	*	*	*	*	*	25
Permit compliance	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	28
Local plan	*	*		*	*		*	*	*	*	*	*	*	*		*	*	*	*	*	*				*	*		*	*	22
Special area plan	*			*				*	*		*		*		*								*	*		*	*		*	12
Other plans, controls			*	*	*		*		*	*	*	*	*	*	*		*	*		*	*	*		*	*	*	*	*	*	22
Direct land management = 6																														
Shoreline in parks	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	29
Protect natural areas	*	*		*	*	*	*	*	*		*	*	*	*	*		*	*	*	*	*		*	*	*	*	*	*	*	25
Dune restoration		*		*	*	*	*			*	*	*	*				*	*							*	*				13
(Re)nourishment				*	*	*	*			*	*	*	*			*	*	*	*	*	*	*			*	*				17
Armoring/repair				*	*		*		*	*	*	*						*	*			*			*					11
Land acquisition				*	*	*	*	*	*		*	*	*	*			*	*		*	*	*	*	*	*	*		*	*	21
Nonregulatory* tools = 5																														
Restrict investment				*	*	*	*				*	*	*	*			*			*			*	*			*			13
Investment incentives						*	*				*	*													*					4
Disclosure							*			*		*				*					*				*					6
Education, tech. assistance	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	29
Fin. Assistance	*	*	*		*		*	*	*	*			*	*		*	*	*	*	*	*	*			*	*		*		20
Research tools = 6																														
Setbacks, risks		*		*	*	*	*	*	*			*	*	*		*	*	*	*	*	*		*		*				*	19
Beach profiles		*		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*		*	*	*	*			*	23
Nat. area inventory*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	28
Technical reports	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	29
Aerial photos	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	29
Sea level rise consideration			*	*	*	*	*		*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	25
Total = 25																														

[a] In Mississippi, all beaches are artificial and open to the public, with no regulation above mean high water. In Pennsylvania, the only major beach is publicly owned and under state management. No information is provided for Georgia and Texas.

[b] Abbreviations: AS, American Samoa; GU, Guam; MP, Marianas Islands; PR, Puerto Rico; VI, Virgin Islands.

SOURCE: Adapted from Bernd-Cohen and Gordon, 1998.

Twenty-three states and territories have some form of shoreline setback policy in place (Bernd-Cohen and Gordon, 1998). Table 4.4 lists coastal setbacks and control zones for each state and territory, any exceptions, and the entities with regulatory responsibility for implementation. The stringency of these policies and degree of enforcement vary both within and across states. New York, for example, has a regulatory setback requirement within erosion hazard areas but has not implemented it in certain locations, such as Fire Island and Westhampton Beach (see Figure 4.9). North Carolina's coastal management regulations are among the strictest in the nation; the state's regulations include mandatory setbacks for new construction within ocean hazard areas, prohibitions on the use of erosion control devices, land acquisition, and local planning requirements (see Box 4.6)

Twenty-seven states define control zones for a broad range of geographic and resource-specific definitions of control areas, and 23 states use a combination of setbacks and control zones. Twenty-eight states regulate the construction of shoreline stabilization structures, and 23 states regulate both pedestrian and vehicular access to the beach and shoreline. Sand mining, sand scraping, dune alteration, and other forms of beach system alteration are regulated by 25 states. To document the implementation of their regulations, most states use permit-tracking systems and compliance tools (i.e., some combination of oversight, field inspection or aerial surveillance, and penalties for noncompliance), but the technical sophistication of, and resources available for, such compliance checks vary significantly (Bernd-Cohen and Gordon, 1998).

FIGURE 4.9 The house with its pilings on Fire Island, NY indicates long-term beach erosion.

(Photo by Stephen P. Leatherman, 1979)

TABLE 4.4 Coastal Setbacks[a] and Control Zones by State: Provisions, Exceptions, Types, and Regulatory Authority

State[b]	Setback Determination and Provisions	Type of Setback (Basis)	Exceptions	Extent of Control Zone (Regulated Area) and Provisions	Regulatory Responsibility
AL	40 feet (ft) landward of crest line (120–450 ft landward of MHWL)	Distance and feature	SF	Construction 40 ft inland from crest to the 10-ft contour regulated; repairs allowed if <50% damaged	State
AK	None			Construction and all new activities in hazardous (flood, storm surge, and littoral process) and erosion hazard areas regulated; inland extent based on land-use districts, zones, and subdivisions. No restrictions on repairs.	State regulations, based on District zones, approved by council
AS	25 ft for residential, 50 ft for commercial development	Standard distance		Land-use permits within 200 ft of MHW denied if subject to shoreline erosion, or if it diminishes access or degrades resources; building permits required in coastal hazard areas; permits required for grading, excavation, fill, and steep slopes	Territory
CA	No state setback, some local setback requirements	n/a	n/a	State coastal development permit required for activities from MHT to 1st public road or 300 ft from beach/bluff or MHT if no beach; covers beaches/dunes, rocky shores within 300 ft of top of coastal bluff, and any development in a locally designated sensitive coastal resource area	Statewide plans and guidelines; local sensitive area designations, implementation
CT	None			All activities regulated above MHW inland to 1,000 ft, or 100 ft from inland boundary of state-regulated tidal wetlands, or within 100-year flood zone	State policies and guidelines, local regulation and implementation
DE	100 ft landward of seaward-most 7-ft elevation above NGVD	Distance and reference contour	Yes, if land not sufficient	Area landward of setback (100 ft landward of 7-ft > NGDV), running along the Delaware Bay and around to the Atlantic (~100 ft wide in north to ~12 miles [mi] wide in south); letter of approval needed for building; post-storm reconstruction prohibited if structure damaged >75% or foundation damaged >50%; exceptions	State for shoreline protection seaward of MHW; local regulation/ implementation of policies in control zone
FL	30-year erosion line for major structures from SHWL	Erosion rate	SF	Permits for activities within an area from SHW to the landward extent of the 100-year floodplain (ranges from a few to several hundred feet wide)	State (delegation to local level not realized to date)
GA[c]	None			Permits required for certain activities and structures from the submerged shoreline lands to the 3-mi limit of state ownership, the sand beaches to the ordinary high water mark, and the “dynamic dune field,” defined as the dynamic area of beach and sand dunes, the ocean boundary that extends to the ordinary high water mark, the landward boundary of which is the first occurrence of either a live native tree 20 ft in height or greater, or of a structure existing on July 1, 1979	State

State[b]	Setback Determination and Provisions	Type of Setback (Basis)	Exceptions	Extent of Control Zone (Regulated Area) and Provisions	Regulatory Responsibility
GU	Ocean shore public access zone (between MLW and 25 ft inland from 2 ft contour)	Uniform zone and contour		Territory-wide land-use plan, zoning, policies, guidelines; permits required for activities in seashore reserves (seaward of the 10 fathom contour, all islands, and inland from MHW to 10 meters or inland edge of public right of way); flood hazard area permit required for new and expansion activities, but not for repairs	Territory
HI	40 ft; along most shorelines to upper reaches of wash of waves, usually evidenced by edge of vegetation growth, debris	Uniform distance (features)	Reduction to 20 ft for small lots, shoreline stabilization only in public interest or in hardship cases	In special management areas (at least 100 yards inland or further to include certain resources or reach up to road), permits for development with adverse ecological impacts or >$25,000; Land Use Commission can reclassify land use; permits required in conservation district	State: **??LUC???**; use permits in conservation district; counties administer SMA, shoreline protection variances
LA	None			In coastal zone, bounded by inland boundary of the intracoastal waterway, highways, natural ridges, and parish boundaries, coastal use permit required; no restrictions on repairs/rebuilding	State guidelines and certification; some local plans/ regulations
MA	None			On tide-flowed tidelands, filled tidal flats between waterway and first public way, or 250 ft from water, state waterway permit required for any new construction or fill; for coastal beaches, dunes, barrier beaches, banks, there are state performance standards but no restrictions on private rebuilding (relocation of willing sellers preferred); within 100 ft of 100-year floodplain or 100 ft of back of beach, dune, flat, marsh, meadow, or swamp, local permits are required for all projects; voluntary local land-use plans may impose additional regulations	State and local
MD	75 ft from NHW	Uniform distance from feature	Fences, boardwalks	On coastal sand dunes, permits required for all activities and within shoreline zone (250 ft from NHM) for multi-family and other development.	State
ME	seaward of frontal dunes (V-zone) and in sea level rise area; no setback in back dunes; setback 75 ft for residential; 25 ft for general development/ commercial; 250 ft from NHWL in natural resources protection areas (100-year flood zone, certain wetlands, and >20% steep slope areas)	Distance and resource		In coastal sand dunes (mapped by state; frontal dunes extend inland 125–175 ft from MHW or from the seaward edge of dune), permit required for any activity; in back dune areas there are size limits, mobility, and elevation requirements; in unorganized areas, same regulations as in municipal shoreline zones (regulations within 250 ft from NHW)	State regulates sand dune areas, protected natural resource areas, unorganized areas; municipal/local handles all else

State[b]	Setback Determination and Provisions	Type of Setback (Basis)	Exceptions	Extent of Control Zone (Regulated Area) and Provisions	Regulatory Responsibility
MI	Sand dune setback 100 ft landward from crest of first landward ridge, not a fore dune; bluff high risk area setback 30-year erosion projection plus 15 ft	Feature, erosion rate, plus uniform distance	Substandard lots approved prior to law	Within designated critical dune areas (within 2 mi of OHWM), permits for development, silvaculture, recreation affecting dune areas; additional regulations for land within 250 ft of critical dune areas possible; from bluffs eroding at >/= 1 ft per year over past 15 years and high-risk erosion areas, extending as far as 1,000 ft landward from OHWM, permits required for development, some reconstruction/repair; for areas within 500 ft of a stream or the Great Lakes, "earth change" permit required for changes to natural cover or topography; local zoning within 100 ft of OHWM of Great Lakes possible	State; local sand dune protection ordinances optional, based on state model ordinance
MS	None	n/a	n/a	None	n/a
NC	Structures less than 5,000 ft^2, setback landward of 30-year erosion rate, crest of primary dune, toe of frontal dune, 60 ft from first line of stable vegetation	Erosion rate, distance, features	Lots plotted before law; structures greater than 5,000 ft^2, 60-year erosion rate or 120 ft from mean vegetation line	Permits for all construction within areas of environmental concern (extending from MLW to a variable distance inland depending on erosion; including ocean-erodible, high-hazard flood, inlet hazard, and unvegetated beach areas on barrier islands); local land-use planning (including hazard mitigation element) mandatory in coastal counties but implementation weak	State for major developments/ projects; local for plans and minor projects based on state standards
NH	100 ft from HOTL bordering tidal waters	Uniform distance from feature	Public good, rebuilding; 5 ft from MHW for primary structures; 75 ft for septic tanks	Activities prohibited or restricted in tidal buffer zone (100 ft inland from HOTL along tidal waters); permits for activities in wetlands (include beaches and dune areas, back dunes, relict dunes); shoreland development permits required for activities, subdivision of area 250 ft landward of OHTL; state subsurface disposal permits and siting setbacks from water bodies	State and local (based on state regulations)
NJ	In V-zone, no residential development; in erosion hazard areas (30 times erosion rate for 1–4 DU, 60 for larger DU) from variable baseline; all permanent structures set back 25 ft from shore protection structure	Feature, erosion rates, variable baseline (bluff or dune crest, first line of vegetation, 8-ft elevation contour), uniform distance	Some beach-related commercial development	Within coastal zone (inland boundary unclear), permits required for all facilities (commercial, industrial, housing > 24 units, since 1994 also SF); since 1988/1990 activities (SF, commercial, and shoreline stabilization) regulated within 500 ft of MHW; development limits in certain areas (e.g., barrier islands) based on environment growth, development potential; no development on dunes, overwash areas, beaches, coastal bluffs	State; voluntary local planning must meet state standards
MP	0–35 ft from shoreline, no construction; 35–75 ft from shoreline, no visual obstruction; 75–100 ft, SF only	Uniform distances		Activities regulated through permit program within APCs (150 ft inland from MHW), i.e., shoreline areas (ocean beaches, rocky headlands, but not top of cliffs), lagoons and reefs, wetlands/mangroves, ports/industrial areas, and major sitings within the territory; uses prioritized (prevention of beach erosion is high priority)	Territory

State[b]	Setback Determination and Provisions	Type of Setback (Basis)	Exceptions	Extent of Control Zone (Regulated Area) and Provisions	Regulatory Responsibility
NY	No moveable structures or major additions within environmental hazard areas	Features or erosion rate	Yes, if setbacks cannot be met and if erosion is not increased	In erosion hazard areas and natural protective feature areas (structural hazard area is 40-year erosion zone and any beach, dune, shoal, bar, spit, barrier island, bluff, wetland, and associated natural vegetation); permits required for all activities; relocations need permits and are required when within 10 ft of receding edge	State and local
OR	No new buildings within "beach zone;" no building on beaches, active foredunes, other conditionally stable foredunes subject to ocean undercutting and wave overtopping, and intertidal plains subject to ocean flooding (V-zone)	Features	In-filling of already developed areas with shoreline protection, on older, stabilized dunes	In ocean shore recreation areas (between extreme low tide and vegetation line), permit required for improvements; seaward of vegetation line, removal/fill permit required for most types of shoreline alteration; statewide land-use goals. apply to state and local permits; special permits for coastal shorelands (at least 100 ft landward of ocean shore); mandatory local plans	State and local
PA	Only setbacks from bluffs, based on recession rate and type of structure: residential, 50 years; commercial, 75 years; or industrial, 100 years	Bluff recession rates	Lots subdivided prior to 1980 if inadequate depth to meet setback requirements	Local planning and zones apply within and landward of setbacks	Local planning, administration of state regulations
PR	6 meters (m) from public right of way; 50 m setback for development from TMZ (shoreline); 2.5 times height of building setback for all structures built within 400 m of TMZ	Uniform distance within 50 m of shoreline; height-dependent setback otherwise	Urban zone lots approved prior to regulation if setbacks cannot be met	Commonwealth-wide land-use policies and zoning districts; activities within 1,000 m (or further to include important resources) of shoreline and on islands regulated,/permitted; flood area permits for activities in flood-prone areas; restrictions on nonconforming uses in submerged lands, tidally influenced land	Territory
RI	50 ft from coastal features or 25 ft from coastal buffer zone; 30 times erosion rate for 1–4 DU, 60 times erosion rate for larger DU in critical erosion areas; dune construction setback on 3 barrier beaches seaward of utilities/wall of existing development; no development on beach face, sand dune, undeveloped barrier beaches	Feature, erosion rate	Water dependent activity, shoreline stabilization, access, public utilities, public welfare	Within 200 ft of a coastal feature, permit required for certain activities; permits tied to zoning, coastal feature protection, and type of activity; construction on or alteration of dune areas restricted or prohibited; on all barrier beaches, new infrastructure prohibited; on undeveloped barriers, construction/alteration prohibited, only soft structural protection; on moderately developed barriers, new development prohibited, maintenance, rebuilding allowed	State

State[b]	Setback Determination and Provisions	Type of Setback (Basis)	Exceptions	Extent of Control Zone (Regulated Area) and Provisions	Regulatory Responsibility
SC	From MHW to crest of primary oceanfront sand dunes	Features	Swimming pools	State policies, local beach management plans are basis for decision in 40-year erosion zone; construction permitted but size- and location-dependent; no erosion control as part of building; exceptions for certain structures and activities; repair and rebuilding restricted depending on degree of damage; removal of structure located on active beach required	State and local
TX	None	N/A		No construction is permitted seaward of the vegetation line. Structures erected seaward of the vegetation line (or other applicable easement boundary) or that become seaward of the vegetation line as a result of natural processes are subject to removal.	State
VA	30-year erosion rate or 20 times local recession rate from MHW for barrier islands	Erosion rate	Public interest activities	On coastal primary sand dunes and beaches, permits required for certain uses	State and some counties/cities for local permits
VI	No obstruction within 50 ft of MLT or seaward of natural barrier, whichever is shortest	Distance		In use districts (consistent with territorial coastal policies), permits required; coastal zone permits required for major and minor activities within first tier whose landward boundary is mapped, based on natural and artificial features	Territory
WA	No state setback, but there may be local setbacks	n/a	n/a	Within 200 ft of shore, shoreline substantial development permit required; local shoreline master plans	Local (with state review)
WI	75 ft from OMHW	Uniform distance	Piers, boat hoists, boathouses	All development within 100 ft of OHWM regulated	State, with local administration of setbacks

[a] Setback distance is measured as a uniform distance (in feet or meters), as a zone of a certain width measured from a defined resource feature, as a function of the site-specific erosion rate, or as a combination of these measures. In summary, 22 states have state-set setbacks. Two states (CA, WA) have local setbacks. Five states (Alaska, Conn., La., Mass., Miss.) have no setbacks.

[b] Abbreviations for territories: AS, American Samoa; GU, Guam; MP, Marianas Islands; PR, Puerto Rico; VI, Virgin Islands.

[c] These data are from Georgia Department of Natural Resources, 1999.

Key:

APC: area of particular concern
DU: dwelling unit
HOTL: high ordinary tide line
MHW: mean high water
MHW(L): mean high water (level)
MLT: mean low tide
NGVD: national geodetic vertical datum
NHWL: normal high water line
OHWL: ordinary high water line
OMHW: ordinary mean high water
SF: single family housing units
SHWL: seasonal high water line
TMZ: territorial maritime zones

SOURCE: Adapted from Bernd-Cohen and Gordon (1998)

BOX 4.6 North Carolina's Setback Policy and Other Shoreline Management Policies

North Carolina's Coastal Area Management Act (CAMA) of 1974 prescribes a shoreline policy that recognizes the unstable nature of barrier islands and storm- and erosion-related coastal hazards. Its primary elements are mandatory setbacks and a no-hardening/stabilization rule in hazardous shoreline areas. The CAMA defines a setback as the minimum distance from the ocean that structures (houses and commercial buildings) can be constructed. The Act also defines areas of environmental concern (AECs) in which its regulations apply. In the so-called ocean hazards areas (including ocean-erodible areas, high-hazard flood areas, inlet hazard areas, and unvegetated beach areas), the setback regulations are as follows:

The setback line is located:

- For small structures (<5,000 square feet [ft^2] total floor area):
  - 30 × long-term annual erosion rate landward of the first line of stable vegetation, unless this line is seaward of the primary dune; in the latter case, the setback is measured from crest of the primary dune; *or*
  - a minimum of 60 ft where erosion rate is <2 ft per year (yr);
- For large structures (>5,000 ft^2 total floor area):
  - 60 × long-term annual erosion rate *or*
  - 30 × long-term annual erosion rate plus 105 ft (if erosion rate is >3.5 ft/yr) landward of the first line of stable vegetation; *or*
  - a minimum of 120 ft from the first line of stable vegetation or measurement line.

No development is allowed on or seaward of the frontal dune. Structures also must be located landward of the crest of the primary dune unless that rule would preclude any practical use of the lot, in which case development may occur seaward of the primary dune, but landward of the erosion setback line. To preserve the protective function of frontal and primary dunes, no development can involve significant removal or relocation of dune sand or dune vegetation. Mobile homes cannot be placed in ocean hazards areas at all unless they are located in mobile home parks that existed prior to June 1, 1979.

The relocation of structures with public funds away from the eroding shore must meet all minimum setback requirements. The relocation of supporting structures and infrastructure (septic tanks and other essential accessories) entirely with nonpublic funds must be relocated the maximum feasible distance landward of the present location; septic tanks are not allowed seaward of the primary dune.

North Carolina also does not allow permanent erosion control structures (bulkheads, seawalls, revetments, jetties, groins, breakwaters) along its open ocean coast. The only exceptions to this rule include cases in which bridges or "only access" roads to substantial population centers on barrier islands, historical sites of national significance, or commercial navigation channels of regional significance are imminently threatened; when such a measure would be vital to public safety and all other nonstructural, soft, or temporary erosion responses have proven inadequate; and the hardening would be limited in scale and extent and not cause adverse impacts to adjacent areas.

(continued,)

BOX 4.6, continued

North Carolina does allow, on a case-by-case basis, experimental erosion response measures that include innovative technology or design. The state also allows one-time temporary erosion control structures in cases in which opportunities for relocation and beach bulldozing have been exhausted. Imminently threatened roads, associated rights of way, principal structures, and associated septic systems may be protected temporarily by sandbags (3–5 ft wide, 7–15 ft long, and up to 6 ft high) placed above mean high water and parallel to the shore. These sandbags may remain in place for a maximum of 2 years from the date of approval for small structures (<5,000 ft^2) or up to 5 years for larger structures (>5,000 ft^2), roads and bridges, or any structure located in a community actively seeking beach nourishment. After that period or when the temporary protection no longer is needed, sandbags must be removed at the property owner's expense unless they have been covered up by sand and vegetated so they look like "natural and stable" dunes. Beach nourishment, beach bulldozing, and dune establishment and stabilization are allowed but require permits depending on the size of the project.

Currently, the CAMA's Coastal Reserve Program and Public Beach and Coastal Waterfront Access Program provide specific authority to acquire coastal property. The latter program was established in part to address storm, flood, and erosion hazards. Because of a lack of state funding, that program has been used rarely since the late 1980s, but a new state fund for land acquisition recently enabled the state to acquire unbuildable lots. In addition, local governments are authorized to acquire land under various sections of the General Statutes. Few owners offered unbuildable lots for public acquisition after hurricanes Bertha and Fran; perhaps more will be forthcoming in the wake of Tropical Storm Dennis in 1999, which lingered for days off the Outer Banks and caused extensive erosion damage.

SOURCES: Godschalk, 1998; Pilkey et al., 1998; Price et al., 1999; Williams et al., 1999).

Planning Tools

Planning tools are designed to guide land-use and development patterns while assuring public safety and infrastructure services. Such plans usually contain or set the stage for enforceable policies, such as those described above. According to NOAA's effectiveness study (Bernd-Cohen and Gordon, 1998), planning tools vary substantially, both in scope and in the geographic extent to which they pertain. They also differ as to whether plans are voluntary or mandatory and in the degree of protection afforded through the plans' provisions.

For example, plans may cover a state's entire coastal zone, the whole state, or only specially defined areas (e.g., inlets, beaches, bluffs, reefs, wetlands, dunes, erosion or hazard areas). States may have a planning framework that sets guidelines and constraints on local plans, or they may encourage or require local governments to develop their own land-use and development plans for either the entire community or specifically defined resource management areas only. The latter approach usually entails some limited state financial and technical support for the development of local plans. In addition, through FEMA's Hazard Mitigation Assistance Program, states and communities can get federal planning and technical assistance grants.

According to the effectiveness study, 28 of the 29 coastal states and territories studied use some type of planning affecting their shoreline areas, 21 rely on local permit delegation in combination with local planning, 23 use special area management plans or other plans; and 10 use more than one planning tool (Bernd-Cohen and Gordon, 1998).

Direct Land Management, Restoration, and Acquisition

All states with federally approved programs under the CZMP also own some stretch of the coast and are responsible for managing these coastal public trust lands and waters (e.g., state parks, wildlife refuges, historic sites, recreational areas). States also often obtain public easements—and usually management responsibility—for privately held land, and they engage in cooperative agreements with other public landholders to jointly manage public land. Most coastal states protect some natural coastal areas deemed particularly worthy or vulnerable to human disturbance, but the degree of protection, use, and management of eroding shores varies.

The majority of states (21) with federally approved programs under the CZMP also have land acquisition programs through which areas worthy of protection or repeatedly affected by coastal hazards and damaging erosion losses can be bought from private owners (Bernd-Cohen and Gordon, 1998). States often pool acquisition funds from various sources, request matching federal funds, and financially and technically assist local governments in their land acquisition projects.

Such intergovernmental collaboration increases the bidding power and number of lots that can be acquired. Generally, land acquisition offers a way to permanently reduce or eliminate vulnerability to flooding and erosion hazards, and, hence, to reduce the long-term economic impact on structures in hazard-prone areas. It also helps to implement or achieve other hazard mitigation goals, such as increases in flood retention capacity, preservation of habitat, and provision of open space and public beach access (Godschalk, 1998). On the other hand, land acquisition frequently provokes objections by local governments (on the basis of property-tax loss, high cost of acquisition, long-term maintenance burden, etc.) and private landowners (on the basis of loss of desirable location, etc.). In oceanfront areas, land acquisition is limited by high land values. It is difficult to compile data on the extent and expense of land acquisition because record keeping is inconsistent across the nation and many states do not maintain records at all (Bernd-Cohen and Gordon, 1998; Godschalk, 1998).

States also are centrally involved in co-funding and designing engineered shoreline protection measures, both hard and soft. Delaware, for example, has adopted a policy of shoreline stabilization through a long-term commitment to beach nourishment as a means of managing erosion. Because they have more financial resources than local governments do, states frequently pay all or the larger portion of the “local share” in USACE shoreline protection projects. Occasionally, states also co-fund shoreline armoring or beach nourishment projects that do not involve the USACE (Duke University Program for the Study of Developed Shorelines, 1998).

States also use other incentive or assistance programs to aid or promote certain shoreline protection or development practices. For example, some states (e.g., North Carolina, Texas, Hawaii) have created, or are in the process of establishing, beach nourishment funds. Occasionally, states provide financial or technical support to communities for the relocation of public or private structures and the creation, restoration, or re-vegetation of disturbed dune areas (e.g., Massachusetts, Maine), or buyouts of repeatedly damaged properties (e.g., New Jersey, Florida, Minnesota, Ohio, Alabama). State agencies concerned with shoreline protection may provide guidelines and encourage only a limited set of mitigation practices even though a wider set of options is legal. For example, in Maryland, Massachusetts, and Hawaii, armoring of the shoreline is currently legal. Yet in these states, as in most others today, shoreline management agencies try to direct protection efforts toward nonstructural and soft engineering approaches because of the threat of, or experience with, the increased erosion and beach loss often associated with hard shoreline protection (Bernd-Cohen and Gordon, 1998; Moser and Cash, 1998). A few states (e.g., Louisiana and

Florida) mandate the beneficial use of dredged materials, requiring that dredged sediment meeting certain quality standards be placed on beach areas in need of sand rather than re-deposited offshore (Bernd-Cohen and Gordon, 1998).

Information Provision - Disclosure and Mapping

In contrast to regulatory measures, nonregulatory tools and processes are designed to influence coastal activities and land-use choices by systematically deterring or promoting certain developments and practices by legal, economic, or other informal means. These measures may or may not be specific to particular coasts or hazards. Some states (e.g., Rhode Island) impose public investment restrictions on certain areas (e.g., erosion-prone areas) to eliminate development incentives for private individuals. Conversely, states may provide investment incentives in less-hazardous areas or for specific types of activities deemed beneficial for shoreline protection. South Carolina, for example, follows a policy of promoting development in certain areas while discouraging development in others (in combination with land acquisition) (Moser, 1997).

Some states (Florida, Louisiana, Maryland, Mississippi, Ohio, Oregon, and South Carolina) have instituted notification or disclosure laws based on the rationale that flooding history, erosion risk, or other hazard exposure data for a particular structure or property is relevant to an informed purchase or development. These states require that this information be made available to a potential buyer or developer in a timely and understandable manner. The underlying assumption is that the disclosure either will deter buyers and developers from choosing hazardous locations or will encourage them to mitigate the hazard (Godschalk, 1998). However, the voluntary disclosure of risks has proven to be an ineffective means of ensuring that this information is public, accessible, and known at the time of purchase or transfer (Godschalk, 1998) (see Box 4.7). Several other coastal states are developing disclosure laws to boost their hazard management and mitigation efforts. A related measure in California is a state-defined limitation on liabilities if structures are built knowingly in hazardous locations.

BOX 4.7 Mandatory Hazard Disclosure Laws: South Carolina, Texas, Massachusetts, and Ohio

South Carolina's ocean-related hazard and flooding notification requirement is established in the state's Coastal Tidelands and Wetlands Act. The seller of a coastal property must notify a potential buyer of the ocean-related hazards prior to the signing of a real estate agreement. The properties and locations affected are determined on the basis of definitions provided in the law. Although all types of properties are affected, South Carolina has no standard form and relies on private enforcement of the policy.

The disclosure requirement in Texas is almost identical to that in South Carolina, except for the reliance on both state and private enforcement. In both states, notification usually is provided, and the programs seem to fulfill their purpose.

Massachusetts, by contrast, requires disclosure only in cases involving risk from coastal flooding. The program places the responsibility for notifying a potential buyer on the seller and/or the real estate agent, uses maps and definitions to identify affected properties, and requires the use of a standard form to notify a buyer prior to the signing of any real estate agreement. State and private enforcement of the policy rests on the threat of triple damages under state unfair trade provisions.

Ohio established a 30-year erosion hazard boundary along the Lake Erie shoreline, effective June 1, 1998. Owners of property located within the 30-year erosion hazard boundary are required to notify buyers of the erosion hazard through the state's standard real estate disclosure form. There has been only one appeal of the erosion hazard mapping boundary.

SOURCE: Godschalk, 1998

Many coastal states identify and map eroding shores and maintain updated information on shoreline change resulting from major storms, inlet migration, or other processes (e.g., beach nourishment projects). Updated maps showing the erosion rates are used to support both regulatory and nonregulatory measures, strengthen post-storm recovery, and identify areas with high post-storm vulnerability.

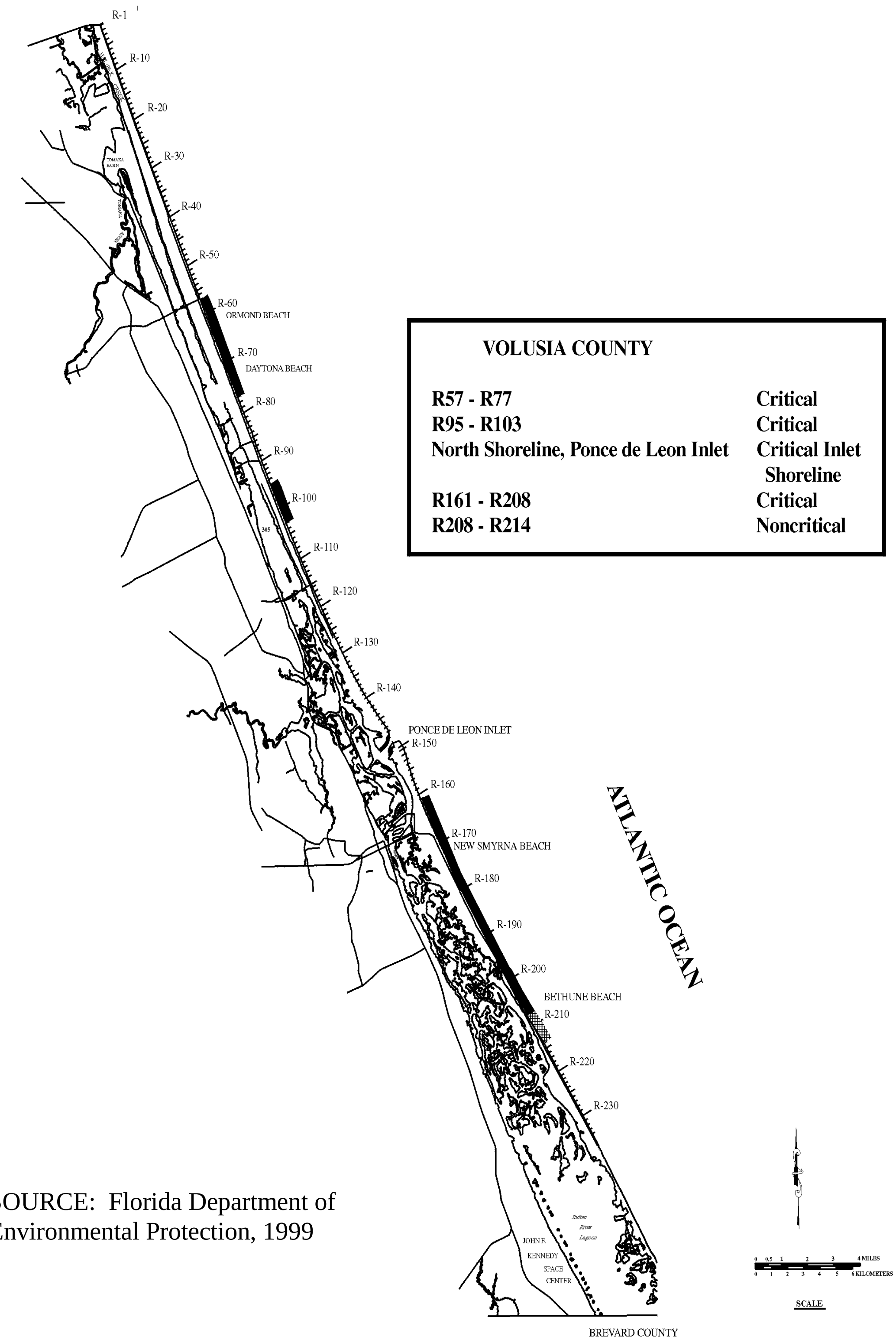
Some states, such as Florida and Texas, provide information on specific areas at greater risk from erosion. Florida, for example, identifies and maps critical erosion areas, defined as "areas where there exists a threat to or loss of one of four specific interests—upland development, recreation, wildlife habitat, or important cultural resources" (Florida Department of Environmental Protection, 1999). Critical erosion areas also may include "peripheral segments or gaps between identified critical erosion areas which, although they may be stable or slightly erosional now, [must be included] … for continuity of management of the coastal system or for the design integrity of adjacent beach management projects."

Figure 4.10 shows the critical erosion areas map for Volusia County, Florida. The map divides eroding shoreline areas into three categories: critical erosion, critical inlet shoreline, and noncritical erosion. Similar maps have been produced for all coastal counties in Florida, spanning 217.6 miles (mi) of critical erosion and another 114.8 mi of noncritical erosion statewide.

As an extension of mere hazard disclosure and mapping, all states with federally approved programs under the CZMP use some of their resources to finance, support, or undertake research; prepare technical reports; perform coastal land inventories; and educate the public and reach out to particular constituencies. Frequently, scientific program staff collaborate with academic researchers (e.g., in Maine, Hawaii, Oregon, North Carolina) in the actual research; at other times, research on coastal hazards is conducted on a consultancy or competitive grant basis by outside researchers (e.g., university researchers, independent engineers). Outreach to specific groups frequently occurs in collaboration with NOAA-funded Sea Grant extension services (e.g., in Wisconsin, Hawaii, South Carolina), state floodplain management programs, or other relevant governmental and nongovernmental institutions. Public education on coastal erosion and other shoreline hazards encompasses direct technical assistance to local planners and decisionmakers or private individuals; information dissemination through World Wide Web sites, coastal journals, or technical newsletters; special events (e.g., conferences, fairs, beach clean-up days, slide shows, field excursions); and public notifications in the mainstream news media or letters to property owners of especially affected coastal areas.

Education and outreach are intended to expand public understanding of, and public debate on, coastal issues. But the duration and effectiveness of public education and outreach efforts vary among states. States also face a significant problem in reaching absentee landowners who invest in shorefront property but do not actually live in the areas for most of the year. Such property owners often are among the most affected by erosion hazards but have little first-hand experience with, or understanding of, coastal dynamics; moreover, they rarely participate directly in the political debate and solution-finding process in the state or community.

FIGURE 4.10 Several critical erosion areas are noted in this map of the Volusia County, Florida, shoreline.



SOURCE: Florida Department of Environmental Protection, 1999

APPROACHES AVAILABLE AT THE FEDERAL LEVEL

Federal programs dealing with coastal hazards generally, and with coastal erosion in particular, have evolved over time. In most cases, they are closely tied to state and local efforts. Like the approaches to erosion management at other levels, federal coastal hazard policies are a combination of attempts to eliminate or reduce risks by modifying the loss potential or hazard, affect the causes of hazards, adjust to losses from hazards, and transfer risks from those most severely exposed to a broader population (Burby, 1998). The following review of federal activities relating to shoreline protection and erosion control reveals an evolution in approach driven by a growing understanding of coastal processes, an increase in coastal erosion problems, and changes in the federal government's role in managing coastal hazards. The range of federal approaches available to manage coastal erosion, shown in Figure 4.11, includes:

1. shoreline protection,
2. provision of federal incentives for state planning,
3. withdrawal of federal subsidies and development incentives,
4. direct regulation,
5. public ownership, and
6. federal disaster assistance.

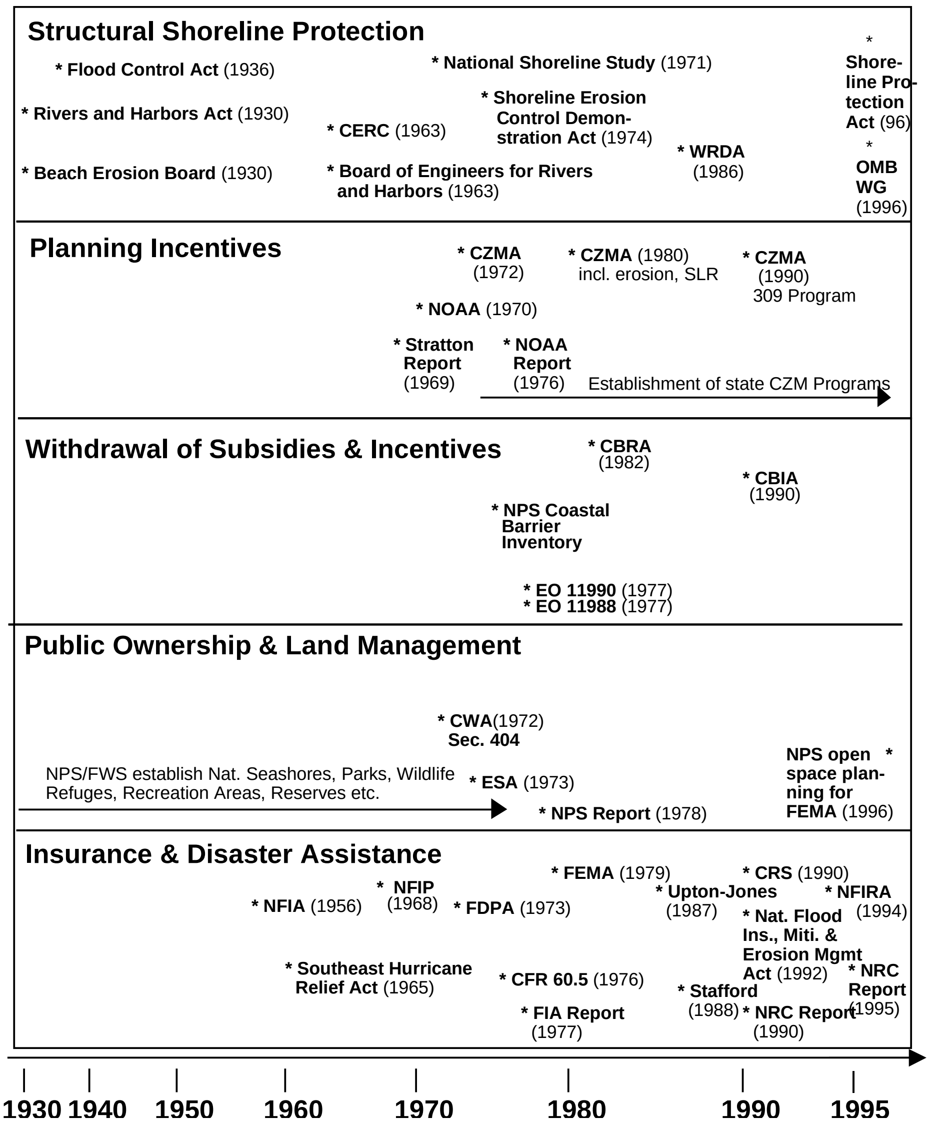
These approaches are discussed below. Policy options for incorporating erosion into the NFIP are described and analyzed in chapter 6.

Shoreline Protection

The federal government conducts shoreline protection projects involving community, state, and/or federal agencies. From the early decades of this century until very recently, the USACE has led federal shoreline protection and erosion control works. The history of the USACE's involvement in shoreline protection reflects the general evolution of federal coastal erosion policies from in situ structural protection (e.g., seawalls, jetties, breakwaters, dredging, sand transfer facilities) to a more flexible range of approaches, including soft engineering approaches (e.g., sand scraping, beach nourishment, dune stabilization) and retreat and relocation (National Oceanic and Atmospheric Administration, 1976; National Research Council, 1990; Platt et al., 1992a; Platt, 1994; Pilkey and Dixon, 1996; Maddox, 1998).

The USACE first began carrying out its mission in 1824, but it did not become responsible for shoreline protection until the early twentieth century (Platt, 1994). For the first six decades of its work in this area, the USACE typically instituted structural, hard engineering responses to local coastal erosion problems.

FIGURE 4.11 Events and laws pertaining to federal shoreline protection date back to the 1930s but have become more numerous in recent years.



Key:

CBRA	Coastal Barriers Resources Act	FIA	Federal Insurance Administration
CBIA	Coastal Barriers Improvement Act	NFIA	National Flood Insurance Act
CERC	Coastal Engineering Research Center	NFIRA	National Flood Insurance Reform Act
CFR 60.5	Federal regulation authorizing mapping of E-zones	NFIP	National Flood Insurance Program
CWA	Clean Water Act (1972), Sect. 404	NOAA	National Oceanographic & Atmospheric Administration
CZMA	Coastal Zone Management Act	NPS	National Park Service
CRS	Community Rating System	NRC	National Research Council
EO	Executive Order (Carter Administration)	OMB WG	Of. of Management & Budget Working Group on Shoreline Protection
ESA	Endangered Species Act	SPA	Shoreline Protection Act
FEMA	Federal Emergency Management Agency	Stafford	Stafford Disaster Relief and Emergency Management Assistance Act
FDPA	Federal Disaster Protection Act	WRDA	Water Resources Development Act

Table 4.5 lists total expenditures for the USACE Shore Protection Program from 1950 to 1993. As of 1993, the USACE had completed the construction of 82 large projects. Twenty-six of these, authorized in the 1950s and 1960s, are not included in the expenditure data because of either their small scope and cost or a lack of sufficient data. The remaining 56 large shore protection projects protected a total of approximately 210 mi of shoreline and cost a total of nearly $1.5 billion (in 1993 dollars) (U.S. Army Corps of Engineers, 1996).

Major projects include both armoring (e.g., seawalls, breakwaters, revetments, groins) and beach nourishment. The list understates the true volume of shoreline protection activities because it does not include projects that are small and specially authorized or that do not require special Congressional authorization. Furthermore, the USACE does not keep track of projects that do not pass the reconnaissance or feasibility phases (i.e., that were denied federal assistance) or are completed without federal involvement (C. Chestnutt, U.S. Army Corps of Engineers, personal communication, August 12, 1998).

TABLE 4.5 Total Expenditures for U.S. Army Corps of Engineers Shoreline Protection Projects 1950–1993 (adjusted to 1993 dollars)

Type of Measure	Federal Cost (millions)	Federal Share (%)	Total Cost (millions)
Initial beach restoration	$426.0	58	$730.4
Periodic beach nourishment	$270.9	64	$420.4
Structures	$153.9	50	$308.5
Emergency measures	$30.2	100	$30.2
TOTAL	$881.0	59	$1,489.5

SOURCE: U.S. Army Corps of Engineers, 1996

In 1971, in response to a Congressional mandate, the research branch of the USACE produced a *National Shoreline Study*, which, prior to the present study by The Heinz Center, was the only nationwide survey of coastal erosion problems (although additional erosion databases have been compiled through academic research) (U.S. Army Corps of Engineers, 1971). Critics of the 1971 study noted several shortcomings, including a lack of clear definition of the various degrees of erosion severity identified in the survey, the use of various measurement methods that made comparison across regions difficult, and the coloring of findings by the agency's political agenda (Platt, 1994).

Even so, the 1971 study marked the beginning of a shift in the USACE's philosophy away from hard structural erosion management and toward soft structural approaches or combinations of the two. The study also recognized that humans cause and exacerbate coastal erosion and propagated a new perspective calling for the inclusion of erosion management in comprehensive coastal zone management (Ricketts, 1986). In 1999, the U.S. Congress, through the reauthorization of the Water Resources Development Act (WRDA, P.L. 106-53), directed the USACE to prepare a report on the state of U.S. shores. This report will provide updated information on the extent of coastal erosion and its economic and environmental effects, and make recommendations regarding appropriate levels of federal and nonfederal participation in shoreline protection.

A comprehensive record of beach nourishment projects of all sizes was compiled by the Duke University Program for the Study of Developed Shorelines (1998) based on searches of publicly available records at the federal, state, and community levels. Table 4.6 provides an overview of the results (Pilkey and Dixon, 1996), showing the beach nourishment experience of U.S. coastal states (except for Pacific states) from 1921 through January 1998. In a separate publication, Duke researchers reported that 30 West Coast beaches along more than 30 mi had been replenished by 1988 (the actual number of nourishment projects is higher because some sites have been nourished more than once) (Pilkey and Dixon, 1996).

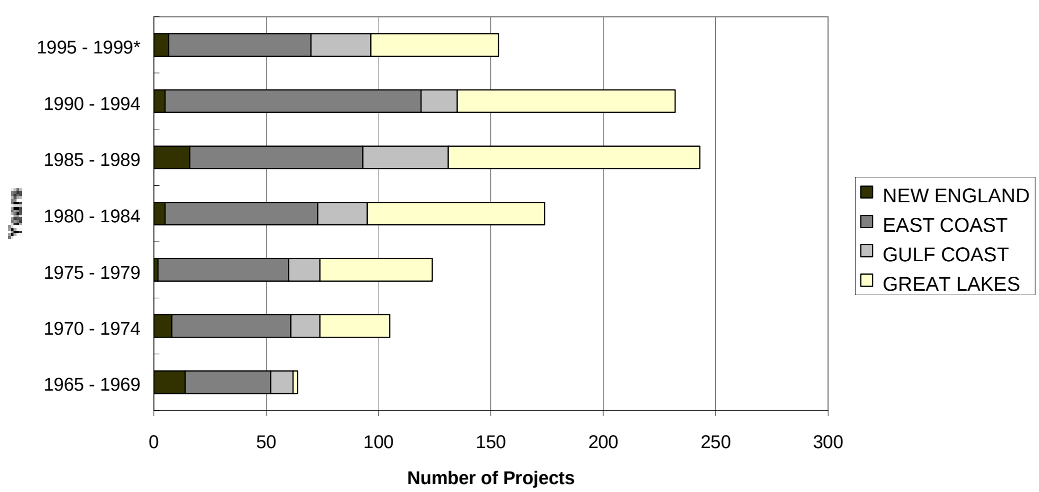
Several noteworthy facts about the practice of beach nourishment can be gleaned from Table 4.6. For instance, East Coast and Great Lakes shorelines lead the list in terms of total number of projects and the re-nourishment ratio (i.e., number of projects per site). New England and the Gulf Coast have had similar numbers of smaller nourishment projects, but the Gulf region had more expensive projects at fewer, repeatedly nourished sites. It is important to note that the regional and state totals of beach nourishment projects reflect not only the physical severity of coastal erosion but also political effectiveness in obtaining funds for nourishment projects.

Also interesting is the cost-sharing picture that emerges from these data. Clearly, the federal government is by far the largest financier of beach nourishment projects, funding more than 77 percent. Projects in which a state is the primary funding source are rare, but states and local governments together take the lead in more than 13 percent of these documented cases. Projects in which local governments and/or private entities are the major sponsors constitute almost 9 percent of the total, a surprisingly large proportion given the high cost of these projects. The fact that nearly 23 percent of projects are funded primarily by state, local, and/or private entities indicates that, even if the cost-benefit ratio of a project does not justify federal funding, there is a significant need, demand, and willingness to protect the shoreline through soft, multi-objective measures, limited only by the financial means of the sponsors. The contributions of nonfederal sponsors also may be related to the long completion time of federal projects (8–15 years) (Pilkey et al., 1998).

The 1999 WRDA reauthorization increases the nonfederal share for periodic beach nourishment on a phased-in basis from the current 35 percent to 50 percent in 2003. The nonfederal cost for initial construction of shore protection projects remains at 35 percent. In addition, the 1999 WRDA requires the USACE to count the flood losses avoided by nonstructural projects just as they do for structural projects in benefit-cost analyses. It also authorizes the USACE to reevaluate (at the request of a nonfederal interest) a previously authorized project and consider nonstructural alternatives in light of this new treatment of benefits.

Regional and national trends over time and across the total number of projects (1,305 nourishment episodes in almost 400 locations) confirm that beach nourishment has become an important practice in shoreline management (see Figure 4.12). Beach nourishment became a significant practice in the early 1960s, reflecting shifts in the national economy as well as changes in the willingness of various administrations and sessions of the Congress to fund large beach nourishment projects (C. Chestnutt, U.S. Army Corps of Engineers, personal communication, August 12, 1998). The profusion of beach nourishment since the 1960s reflects a change in approach to shoreline protection within the coastal engineering community, increasing recognition of the harmful ecological and aesthetic impacts of shoreline hardening, and the realization that, although property might be better protected from erosion with armoring than without, the beaches themselves are the most frequent casualties of shoreline hardening. The loss of beaches, in turn, has severe economic impacts on the tourism and recreation industries, and it usually necessitates beach nourishment for an indefinite period of time (Pilkey and Dixon, 1996).

FIGURE 4.12 Beach nourishment has become increasingly popular in the United States since 1950.



*Note: Three years of data scaled up to 5-year basis

SOURCE: Adapted from Duke University Program for the Study of Developed Shorelines, 1998.

TABLE 4.6 Regional and State Summary of Beach Nourishment Experiences (1921–1998)

State[a]	No. of Projects	No. of Sites	Projects per site	Total Adjusted Cost (in 1996 $)[b]	Main Funding Source (in %)[c]			
					Federal State	State/ Local	Local/	Private
NEW ENGLAND								
ME	15	6	2.50	6,778,180	100.0	0.0	0.0	0.0
NH	8	3	2.67	25,575,329	71.0	0.0	16.1	12.9
MA	81	62	1.31	56,410,146	87.5	0.0	12.5	0.0
RI	11	8	1.38	3,255,838	50.0	0.0	0.0	50.0
CT	44	37	1.19	48,259,564	50.0	0.0	50.0	0.0
Reg. Total	159	116	1.37	140,279,057	66.3	0.0	24.8	8.9
EAST COAST								
NY	73	25	2.92	523,099,957	63.2	0.0	5.9	30.9
NJ	124	43	2.88	312,720,819	54.4	0.0	42.7	2.9
DE	33	13	2.54	46,895,882	55.6	22.2	8.9	13.3
MD	6	1	6.00	65,977,063	83.3	0.0	16.7	0.0
VA	48	3	16.00	78,814,630	68.8	0.0	0.0	31.3
NC	108	16	6.75	146,156,213	93.9	0.0	2.0	4.0
SC	28	13	2.15	90,034,254	48.2	0.0	22.2	29.6
GA	8	2	4.00	34,062,300	62.5	0.0	0.0	37.5
FL	144	41	3.51	443,204,832	73.6	0.0	19.1	7.3
Reg. Total	572	75	7.63	1,740,965,951	68.9	2.0	16.0	13.2
GULF COAST								
FL	113	39	2.90	224,752,576	70.8	0.0	26.4	2.8
AL	2	2	1.00	1,870,000	100.0	0.0	0.0	0.0
MS	13	4	3.25	56,052,218	41.7	0.0	58.3	0.0
LA	16	4	4.00	54,529,849	50.0	0.0	50.0	0.0
TX	14	6	2.33	24,637,623	80.0	0.0	10.0	10.0
Reg. Total	158	55	2.87	361,842,265	67.6	0.0	29.6	2.8
GREAT LAKES								
Erie	54	9	6.00	77,905,646	89.6	0.0	0.0	10.4
Huron	26	7	3.71	5,168,858	92.3	0.0	7.7	0.0
Ontario	3	2	1.50	2,847,266	100.0	0.0	0.0	0.0
Superior	53	11	4.82	9,551,403	100.0	0.0	0.0	0.0
MI	280	30	9.33	100,804,089	93.8	0.0	1.1	5.1
Reg. Total	416	59	7.05	196,277,262	94.0	0.0	1.3	4.8
NATIONAL TOTAL	1305	387	3.37	2,439,364,535	77.2	0.9	13.3	8.6

[a] No data are available for the Pacific Coast states or island territories; therefore, the national total underestimates the actual total.

[b] Total adjusted cost is the total estimated cost adjusted to 1996 dollars. Total estimated cost includes both known costs and estimates for projects with unknown costs. Estimates are determined by using the mean cost by funding category or the mean regional cost in project-year dollars.

[c] The main funding source is known for roughly 89 percent of all projects; other levels may share the costs. Percentages may not add up to 100 because of rounding.

SOURCE: Duke University Program for the Study of Developed Shorelines, 1998

With this increase in beach nourishment activity, more research than ever is being conducted on the environmental and economic impacts of such projects (e.g., Cordes and Yezer, 1995; National Research Council, 1995; Pompe and Rinehart, 1995). Researchers have found that the economic benefits of beach nourishment (in terms of both averted storm impacts and recreational use of beaches) are significant in cases in which the replenished beach remains in place for multiple years (see Figure 4.13) (Pilkey and Dixon, 1996). But a long-term commitment to continuous re-nourishment, especially after unpredictably spaced events such as major storms, poses an enormous financial challenge to sponsoring agencies (National Research Council, 1995; Pilkey et al.,1998). Experience with the durability of replenished beaches has been highly variable because of unpredictable weather events, differences in sediment quality and grain size, significant scientific uncertainty about littoral currents and sediment transport conditions, and inconsistency in project construction quality. Some beaches, such as Miami Beach (a $64 million project completed in 1981), are fairly stable and considered “successful” nourishment projects, whereas others, such as Ocean City, New Jersey (a $5 million project completed in 1982), washed away within a few months (National Research Council, 1990; Pilkey and Dixon, 1996).

Many researchers agree that the impacts on ecological communities in the source area, immediate disposal area, and downdrift from the nourished beaches are not fully understood (Marsh and Turbeville, 1981; Naqvi and Pullen, 1983; Gorzelany and Nelson, 1987; Nelson, 1993; Rakocinski et al., 1996; Hillyer et al., 1997). There are indications of some relatively short-lived but still significant impacts on burrowing organisms, which have difficulty penetrating the hard, artificial beach surface. Sand accumulating on near-shore coral reefs appears to add significant stresses to, and can even destroy, those communities (C. Fletcher, University of Hawaii, Department of Geology and Geophysics, personal communication, March 12, 1998).

The recent history of the USACE’s involvement in federal shoreline management is marked—in large part because of the economics of continual shoreline protection—by policy struggles between the legislative and executive branches of the federal government and even within the Corps itself, between the legacy of hard engineering responses to coastal erosion and calls to retreat from the receding shoreline. In 1995, the Clinton Administration recommended that all federal participation in the construction of new shore protection projects be terminated and directed USACE districts to refrain from proposing new shoreline protection projects for fiscal year 1997. The Congress rejected this proposal and continues to appropriate funds for shore protection projects (American Coastal Coalition, 1998a, 1998b).

The USACE thus continues to carry out hard structural shoreline protection and beach nourishment. Yet it also recently suggested, in its Challenge 21 proposal to the Congress, that at-risk houses and communities be relocated out of the floodplain *before* damage occurs—a policy proposal very much akin to FEMA's Hazard Mitigation Assistance Program (Maddox, 1998). In the 1999 WRDA, the Congress authorized Challenge 21, formally known as the Flood Mitigation and Riverine Ecosystem Restoration Program, and provided $200 million over the next 5 years in funds, with a cap on the federal cost per project at $30 million. This program is designed to finding more-sustainable solutions to flood problems by examining nonstructural solutions in flood-prone areas while retaining traditional measures where appropriate.

FIGURE 4.13 Erosion is very serious in Ocean City, MD, as shown here after a winter nor'easter. This was taken prior to beach nourishment.

(Photo by Stephen P. Leatherman, 1983)

Federal Incentives for State Planning

A second, indirect federal approach to shoreline protection is to provide states with incentives to incorporate coastal hazards into their management and planning. In the late 1960s, the federal government began developing a federal coastal zone management program, an effort that, in 1972, resulted in the Coastal Zone Management Act (CZMA) (Brower and Carol, 1984; Godschalk, 1992; Platt, 1994). The Act serves as a framework legislation that sets broad national policy goals but leaves it to the states to decide whether to participate in the federal CZMP and how to implement those goals. To assure adherence to national coastal policy goals, state coastal programs need federal approval and are regularly reviewed and updated. With federal approval, states can receive funds and technical assistance from NOAA's Office of Ocean and Coastal Resource Management (OCRM) to implement their program goals.

The 1972 CZMA recognized coastal erosion as a significant concern but did not contain any provisions dictating how to deal with it. In large part, erosion was thought to be the management responsibility of the USACE, and, to the extent that it was seen as a land-use issue, perceived as a local regulatory responsibility. The influential report *Natural Hazard Management in Coastal Areas* (National Oceanic and Atmospheric Administration, 1976) paid explicit attention to coastal flooding and coastal erosion. Around that same time, a House of Representatives committee report also recommended including a shoreline erosion planning process within the CZMA to encourage states to assess their erosion problems and develop possible management strategies. This planning process was included in the 1976 reauthorization of the CZMA (P.L. 94-370). The 1980 reauthorization (P.L. 96-464) added coastal hazards, erosion, and sea level rise to the range of pressures on coastal resources (Section 303[2]B) but did not include any performance standards for hazard mitigation.

In 1990, the CZMA was reauthorized (P.L. 101-591) and substantially strengthened through the creation of the Section 309 Enhancement Grants Program. Through this program, states can receive additional funds to strengthen their programs in eight areas, including natural hazards management and the consequences of sea- and Great Lakes-level rise. A review of Section 309 enhancement activities across ocean-bordering and Great Lakes states found that one of the three most frequently cited and funded priority areas was coastal hazard management; the other two were cumulative and secondary impacts of coastal development and wetland preservation (Bernd-Cohen et al., 1995). Although previous federal support for the states' coastal zone management efforts contributed to the recognition and understanding of coastal hazards—and encouraged but did not require states to deal with these problems—the Section 309 program holds states accountable by withholding federal funds if states do not achieve or demonstrate program changes. Thus, with hazard management clearly a critical enhancement area, the federal incentives approach has been strengthened. Moreover, NOAA's recent effectiveness study concluded that the states have successfully created, implemented, and refined planning tools and a variety of regulatory controls on development in high-hazard areas.

The National Estuary Program administered by the U.S. Environmental Protection Agency (USEPA), in place since 1987, is another important program of federal incentives for states and communities. Currently encompassing 28 estuarine areas nationwide, this program is designed to preserve, restore, study, and make accessible coastal wetland areas. Program decisions and activities are carried out by committees of local government officials, private citizens, and representatives from various federal agencies, academic institutions, industry, and estuary user groups (U.S. Environmental Protection Agency, 1999).

Withdrawal of Federal Assistance and Development Incentives

One of the long-standing debates in coastal hazards management is whether or not, and to what extent, governmental assistance (e.g., direct incentives, disaster relief, insurance, shore protection activities, infrastructure provisions) actually promotes rather than deter development and growth in hazardous coastal locations (Cordes and Yezer, 1995; Leatherman, 1997; Federal Insurance Administration, 1998; Shipp-Evatt, 1999). In the late 1970s, damages from coastal disasters, especially on the most exposed and fragile coastal barrier islands, reached unprecedented levels. As a result, significant changes were made in federal policy on barrier island development.

Since the enactment of the National Environmental Protection Act (NEPA) in 1969, EISs have been required for development projects on barrier islands. In addition, the amended 1976 CZMA, the 1977 Clean Water Act (CWA) (P.L. 95-217), and President Carter's Executive Orders 11988 and 11990 of 1977 were aimed in part at restricting barrier island development. Despite these policies, rapid development continued unabated on barrier islands. In another attempt to control development, the 1982 Coastal Barrier Resources Act (CBRA) (P.L. 97-348) established the Coastal Barrier Resources System (CBRS). The Act is restricted to designated undeveloped barrier islands and does not apply to developed—but equally vulnerable—barrier islands. Moreover, the Act does not explicitly prohibit development on barrier islands, but rather restricts federal expenditures within designated CBRS units. As one recent review found, "development pressure in most of the areas studied existed before NFIP and continued even after NFIP was selectively withdrawn" (as in the case of the CBRA) (Shipp-Evatt, 1999). In addition, the policy of issuing no flood insurance in the CBRS has proven difficult to implement, although this may be less of a problem in the future as mapping and geographic analysis tools become more widely available at the local level. A 1992 report by the U.S. General Accounting Office (GAO) "found not only that significant new development continued to occur in certain CBRS units after the law was enacted, but also that (national flood insurance) coverage was written on 9% of the residences sampled" (Pasterick, 1998). Finally, the CBRA has been highly vulnerable to political pressures in the Congress, as evidenced in the continuing political maneuvering to redraw the boundaries of the CBRS (e.g., Bettelheim, 1998; Caribbean Conservation Corp., 1998).

In 1990, the Congress strengthened the law and extended the CBRS substantially with the passage of the Coastal Barrier Improvement Act (P.L. 101-591). The CBRS originally was composed of 186 units encompassing 250,000 acres. Today, the U.S. Fish and Wildlife Service (FWS) administers a system that includes 585 units in 22 states, Puerto Rico, and the Virgin Islands, adding up to almost 1.3 million acres and approximately 1,200 mi of shoreline (U.S. Fish and Wildlife Service, 1998a). There are also 274 "otherwise protected areas," a category added by the 1990 Act for barrier islands within lands reserved for conservation purposes and for which flood insurance is similarly not available (U.S. Fish and Wildlife Service, 1998b).

Direct Regulation

Another federal approach to the management of coastal erosion is direct regulation of activities in vulnerable areas. Although land use and planning regulations are largely under the purview of state and local authorities, the federal government reserves the right to regulate activities that affect environmental protection. Among the pertinent pieces of regulation, the Clean Water Act (CWA), through which the U.S. Environmental Protection Agency (USEPA) becomes involved in shoreline protection matters, is the most significant. Section 404 of the Act requires permits for dredging and the discharge of dredged and fill materials. Section 404 is administered by the USACE, which grants permits for beach nourishment, replenishment activities, and wetland development. The permits are reviewed according to USEPA guidelines, which are based on a number of federal environmental policies and laws (e.g., the NEPA, Endangered Species Act [93-205]). The USEPA also requires EISs or assessments for projects and retains final permitting authority.

Public Ownership and Management

The federal government also can address coastal erosion through the purchase of land and the management of publicly owned land. Acquisition programs have not been widely used because of the high cost of coastal properties. Nevertheless, under the lead auspices of the U.S. Department of the Interior, particularly its National Park Service (NPS) and FWS, and to a lesser extent through NOAA, the federal government has acquired and manages a wide variety of public lands along the coast, including

- national seashores and lakeshores (228,716 acres);
- CBRS units (1.3 million acres, 1,276 mi of shoreline);
- portions of military lands (e.g., Camp Pendleton, Cape Canaveral);
- national marine sanctuaries;
- homes purchased in buyout programs; and
- cultural features (e.g., Cape Hatteras) (National Oceanic and Atmospheric Administration, 1998; National Park Service, 1997).

The reserves managed by NOAA cover nearly 440,000 acres of land and water (National Oceanic and Atmospheric Administration, 1996). Federal ownership of shore lands is frequently complemented through adjoining state, local, and private land ownership, where the land is held in trust and protected from development through conservation easements.

Until 1978, the NPS attempted to stabilize eroding shores under its authority. Since then, despite some ongoing internal debates, it generally has adopted a "let nature have its way" policy, trying to avoid intervention in natural shoreline processes. At Cape Hatteras National Seashore, the NPS have been actively building dunes to prevent overwash and flooding of the main Outer Banks highway (e.g., Route 12). Conflicts with neighboring property owners (both public and private) negatively affected by the NPS policy have led to some soft forms of accommodation, dune stabilization, and relocation of park facilities (Kuehn, 1981; Platt, 1985; Mantell and Duerksen, 1987; Platt et al., 1992a). The long debate over the relocation of the Cape Hatteras lighthouse is a most prominent example. Since 1996, the NPS also has supported FEMA in its post-disaster open space planning process through its Rivers and Trails program (Hanson, 1996).

In 1999, the Clinton Administration launched the Lands Legacy Initiative, a land preservation package totaling $1 billion aimed at the protection and rehabilitation of a variety of vulnerable land and ocean areas, including coastal wetlands, estuarine areas, reefs, fisheries habitats, dredge areas, etc. This proposal allocated $90 million dollars, a 55 percent increase, to the Coastal Zone Management Act Program to help states implement Critical Coastal Area Management and Restoration Plans (NOAA, 1999a; NOAA 1999b). These funds can be used to acquire lands, undertake additional efforts to protect wildlife habitat, protect life and property from coastal hazards, and revitalize ports and urban waterfronts (White House, 1999). The initiative again marks the Administration's shift from its previous position against all shoreline protection policy toward a policy that places beach nourishment, erosion management, and open space acquisition at its center. In the Fiscal 2000 Omnibus Appropriations Bill (H.R. 3194 and Public Law 106-113), the 106th Congress set aside $600 million for the Lands Legacy Initiative, including $450 million for the Land and Water Conservation Fund, an increase of more than $85 million over the previous year's funding (Schowengerdt, 1999). A total of $420 million was set aside in the LWCF for Federal land acquisition funds, including $26 million to manage and protect marine sanctuaries and coral reefs (Wilderness Society, 1999).

In addition, FEMA's Hazard Mitigation Grant Program provides funds to states and communities to implement long-term hazard mitigation measures following a major disaster declaration. The program can be used to fund projects to protect both public and private property, including (but not limited to) land acquisition. Under this program, FEMA does not purchase land directly; rather, the local government purchases and holds title to the land. A deed restriction then is placed on the property requiring that the local government maintain the land as open space (Executive Office of the President, 1998).

Finally, the 1988 Stafford Disaster Relief and Emergency Assistance Act (P.L. 100-707, Section 5170c) provides for the possibility of using up to 15 percent of the “estimated aggregate amount of (disaster assistance) grants to be made” for mitigation projects, including property acquisition and relocation assistance (i.e., movement of structures out of high-risk flood and erosion areas). The funds authorized through the Stafford Act can be used for all (insured or uninsured) properties in disaster areas eligible for federal assistance as long as the property acquired, and from which a structure has been removed, is kept as open space or in recreational use in perpetuity thereafter. Critics argue that the buyouts can result in a payment under the NFIP to the property owner that is much larger than a claims payment and, hence, serve as a deterrent to the purchase of flood insurance (Pasterick, 1998). This shortcoming has been acknowledged by FEMA, which currently is trying to coordinate its approaches.

Federal Disaster Assistance

Federal Disaster Assistance was not originally designed to address erosion hazards, but over the years, emergency erosion management was included. The Federal Disaster Assistance Program began modestly with the Disaster Relief Act of 1950 (P.L. 81-875), which marked the first of a series of laws that would progressively commit the nation to spending tens of billions of dollars on relief and recovery from natural disasters. Initially, its benefits were limited to covering local public costs; later, the benefits would be extended to include private enterprise and individuals as well. After the Disaster Relief Act of 1970 (P.L. 91-608), the federal government assumed a permanent role as the primary source of funds and expertise for dealing with major (and some lesser) disasters. As originally established by the Congress, the federal program was to be limited in terms of the federal assistance and funding to be supplied, and contingent on a disaster declaration by the President that federal assistance was required to supplement state and local capabilities. These limitations have been greatly eased over time, and disaster declarations are being issued more readily and for wider areas than they were in the past. In fiscal year 1996, a record 72 declarations were issued, followed by 49 in 1997 and 62 in 1998. In addition, the costs of disasters to the federal government have risen dramatically.

FEMA and to a lesser extent other federal agencies provide post-disaster assistance, which in some cases is related to coastal shorefront development and protection. According to Platt (1999), the scope of both individual assistance and public assistance for U.S. disasters is very broad. Individual assistance includes temporary housing, individual and family grants, unemployment compensation, food coupons, crisis counseling, and legal services. Public assistance covers debris removal; repair, restoration, or replacement of public facilities of many types (including beaches and trees in certain cases); community disaster loans to cover shortfalls in local tax revenue due to a disaster; and emergency response costs of states and local governments. All of the foregoing are subject to a 25 percent nonfederal cost share, unless it is reduced or waived by the President. The 1994 NFIRA changes strengthened requirements to purchase flood insurance as a condition of receiving disaster assistance grants and marked the beginning of the federal policy of linking disaster assistance to hazard mitigation to prevent or minimize future losses.

The federal government also offers assistance to victims of disasters through Small Business Administration (SBA) Disaster Loan Program, which provides assistance not only to small businesses but also to homeowners, tenants, and nonprofit organizations. Loans are made to such victims of disasters to help cover uninsured losses. Most SBA loans are made at below-market interest rates for long terms (up to 30 years); the borrowers' savings on interest as compared to market rates constitutes a federal subsidy. Disaster victims deemed incapable of repaying a loan (e.g., from the SBA) can obtain individual and family grants from FEMA. However, these grants are small (the maximum amount per grant is $13,000) and intended to cover only immediate recovery needs.

Finally, the USACE can assist communities in post-disaster shore protection efforts. As of 1999, emergency beach repair projects costing up to $7 million are funded through the USACE's annual budget and do not require further Congressional approval (U.S. Congress, 1999).

ROLES AND RESPONSIBILITIES BY LEVEL OF RESPONSE

As outlined in this chapter, no single entity is responsible for responding to coastal erosion, and there is no single solution or set of solutions that fits the many different coastal situations along U.S. shores. The various approaches to erosion management available to individuals, communities, states, and the federal government are summarized in Table 4.7.

Overall, states are leaders in studying and devising policies, land-use plans, regulations, building standards, and other programs for addressing coastal storms, floods, erosion, and in studying the underlying causes of sea level rise, cumulative development in shorefront areas, and shoreline protection. States differ widely, however, in their specific institutional and managerial approaches; they also vary significantly in their needs for, and length of experience with, different strategies. States with the most comprehensive shoreline management programs tend to have:

- strict enforcement of building codes,

- land use regulations,
- strong public education and outreach programs, and
- coordination with federal and local agencies regarding shore protection and management.

The federal government has primary roles in major soft and hard structural shoreline protection projects; offering research, planning, and management incentives to states and communities; direct regulation; public ownership of significant stretches of coastal areas; and in providing for disaster assistance, hazard mitigation, and flood insurance. It also restricts federal expenditures within coastal barrier resource system units and regulates development in wetland areas. Moreover, federal agencies make risk information available, either directly or indirectly, in various formats to all levels of government and to individuals. Any changes to the NFIP need to be viewed within the broad policy and decision-making context described in this chapter as well as the realities of different shoreline characteristics, including the degree of development, local economic resources, and severity of the erosion problem.

TABLE 4.7 Summary of Approaches to Erosion Management by Level of Response

Management Options	Individuals	Communities, Local Governments	States	Federal Agencies
Regulatory	n/a Comply with or exceed regulations/rules on setbacks, shore stabilization, building codes, etc.	Zoning, shoreline setbacks, control zones, dune and shore habitat protection, building codes, mitigation standards, shoreline stabilization rules, implementation of NFIP	Setbacks, control zones, shoreline stabilization rules, building codes, beach access, dune protection, permit tracking and compliance; implementation of CZMA	Wetland alteration; dredging, fill disposal; species and habitat protection; NFIP rules and regulations; CBRA regulations
Planning	n/a Comply with land-use plans, ordinances	Subdivision and special hazard area ordinances; comprehensive land-use plans (voluntary, mandatory/delegated from state level)	Mandatory or voluntary land-use plans, special hazard area plans, financial/ technical assistance to communities	CZMA incentives for state planning, hazard mitigation; assistance for hazard mitigation plans
Non-regulatory	n/a Respond to (dis)incentives, request hazard disclosure in real estate transactions	Location of public facilities in non- or least hazardous areas, transfer of development potential to non-hazardous areas, relocation programs, limitation on infrastructure development in hazardous areas, beach management	Public investment restrictions in hazardous areas, investment incentives in non-hazardous areas, disclosure laws, incentives/ assistance for shore protection, beneficial use of dredged material policies	NFIP insurance and CRS, CBRA restrictions on federal expenditures, USACE shoreline protection/ flood mitigation projects, nourishment
Land ownership and management	Dune restoration and stabilization	Structure, property, and development potential acquisition; beach management; dune preservation, restoration	Land ownership/ management, land acquisition and open space preservation, public easements on private land	Land ownership/ management (NPS, FWS, NOAA, USEPA); land acquisition; open space preservation
Research, education, outreach	Self-education, information gathering	Co-funding and participating in research, impact assessments; public education; informing of at-risk population	Funding /support/con, supporting, conducting research; public education and outreach	Funding, supporting, conducting research (NOAA, FEMA, FWS, USGS, USEPA, USACE, etc.); public education and outreach

Key:

CBRS	Coastal Barrier Resources System	NOAA	National Oceanic and Atmospheric Administration
CZMA	Coastal Zone Management Act	NPS	National Park Service
FEMA	Federal Emergency Management Agency	USACE	U.S. Army Corps of Engineers
FWS	U.S. Fish and Wildlife Service	USEPA	U.S. Environmental Protection Agency
NFIP	National Flood Insurance Program	USGS	U.S. Geological Survey

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5.

THE ECONOMIC IMPACTS OF EROSION

Approximately 300,000 to 350,000 homes and other buildings are located in the first 500 feet (ft) of land along the U.S. coastline, outside of major urban areas.[9] Although the water's edge is an appealing place to live, it is also a risky one, and many of these homes will be damaged by flooding or coastal erosion over the next several decades.

This chapter focuses on the extent of the coastal erosion problem both today and over the next 60 years assuming no changes are made to current coastline management or policy. A conceptual model showing flood and erosion processes on the low-lying shorelines of the Atlantic and Gulf of Mexico, and the bluff shorelines of the Pacific and Great Lakes is described. Projections of expected damage from flooding and erosion within the field surveyed communities are estimated within three progressively narrow risk zones – 500 feet inland from the shoreline, the V-zone, and the 60-year EHA. The estimates of expected damage are extrapolated nationwide. Analyses of the effect of erosion on property value and rates of coastal development are presented in this chapter and considered in the analysis of policy options in chapter 6. Chapter 6 describes a series of possible changes in policy and discusses how these changes might alter the trends observed today.

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[9] As discussed later in this chapter, this estimate excludes structures in the high-density portions of major urban areas such as New York, Los Angeles, Chicago, and Miami.

Approximately 85,000 homes are located within a 60-year erosion hazard area (EHA), that is, on low-lying land or bluffs likely to erode into the ocean or the Great Lakes over the next 60 years. Within the high flood hazard V-zones of the Atlantic and Gulf of Mexico coasts, erosion damage almost doubles the risk of damage from flooding alone. Along the Pacific and Great Lakes coasts, where bluffs are common, the risk from cliff or bluff erosion dominates. Nationwide, erosion may be responsible for approximately $500 million in property loss to coastal property owners per year, including both damage to structures and loss of land.

These conclusions are based on detailed field measurements and mail survey information collected on approximately 3 percent of the buildings located within about 500 ft of the shore. As explained in greater detail in Appendix C, The Heinz Center sent field survey teams to measure and photograph 11,450 structures in 18 counties. Additional information on these same structures was obtained from county assessor and similar offices, and detailed questionnaires mailed to the owners. Data was collected and analyzed on 120 miles of shoreline, or about 1 percent of the U.S. coastline outside of Alaska and Hawaii. This is far more information than ever has been assembled before on the narrow, risky coastal edge. Although the impact estimates below are reconstructions of the past and projections of the future, they present the best picture available of the impact of coastal erosion.

FLOOD AND EROSION DAMAGE TO COASTAL STRUCTURES

This chapter simplifies the flood and erosion processes described in chapters 2 and 3 to help untangle the complex and highly related physical and engineering aspects of these events in ways that are meaningful to policy interventions such as insurance and mitigation. Homes, businesses, municipal buildings, recreational facilities and other structures built on the shoreline face a variety of risks. They are buffeted by occasional severe tropical or extra-tropical storms and may be damaged by flooding, erosion, and wind. Such storms occur only periodically, and, after they hit, may not recur for many decades—or again the next year.

The risk of damage from flooding is greatest within a zone running along the ocean that typically spans a few tens of feet to a few hundreds of feet in width, although occasionally much further inland in low lying areas. This V-zone—or high-velocity zone—is defined for the most part by the height of the waves that are expected from a storm of the size that has a 1 percent chance of occurring in any given year. As explained in chapter 3, coastal erosion is considered in flood zone mapping only retrospectively (i.e., through flood zone remapping) but not prospectively.

Structures located in areas that are susceptible to erosion are subject to another, rather different type of risk. Severe storms not only directly cause structural damage, but also can erode away the protective beach, dunes, and eventually the land beneath a building's foundation (see Figure 5.1). After a storm, it may be impossible to distinguish between structural damage caused by the enormous force of a wave crashing into a house and damage caused by that same wave undermining its foundation. Regardless, in an eroding area, the land and house will sooner or later be lost.

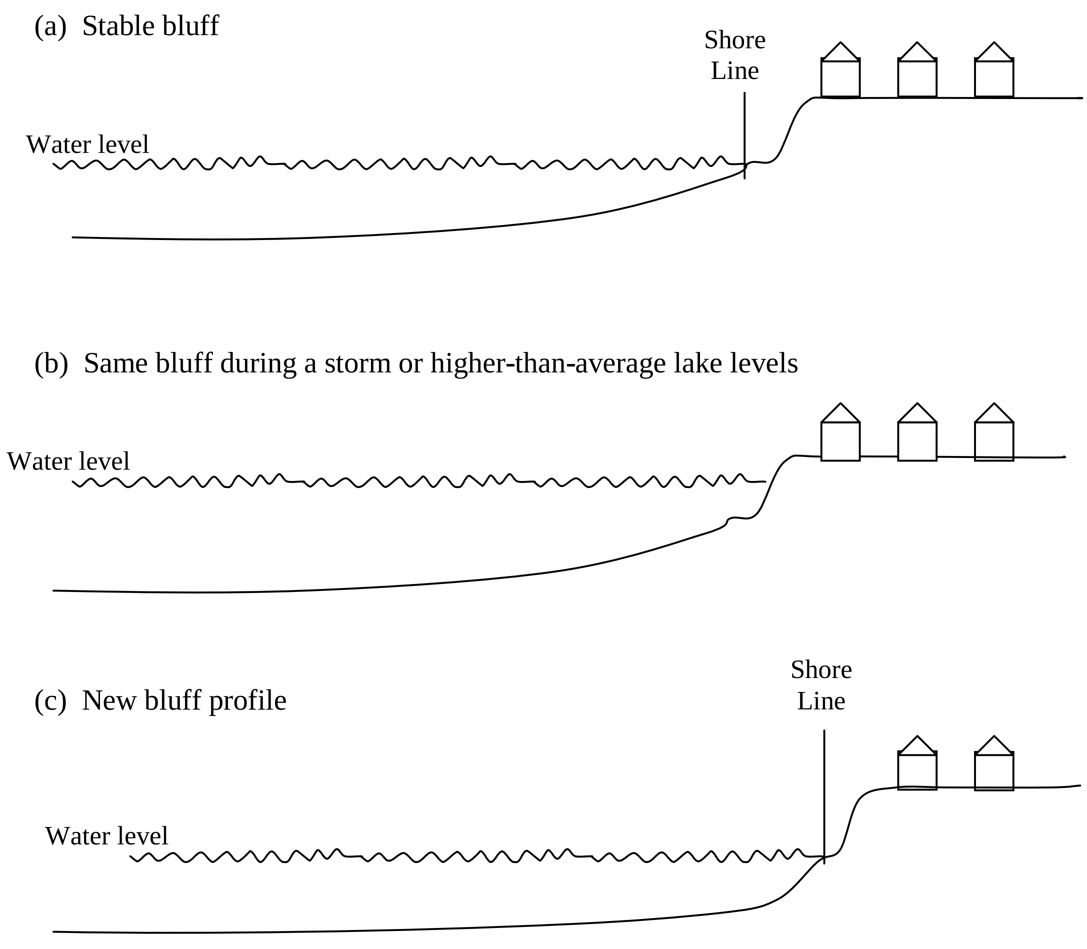
The distinction is clearer when considering houses built on high bluffs above the oceans (as often occurs along parts of New England and the West Coast) or high cliffs along the Great Lakes. Flood damage *in* the house is not a problem; the water never gets as high as the bluff. However, the bluff beneath the house can erode, and when the foundation is reached, the house will be lost or damaged sufficiently to become uninhabitable. Thus, although few of the houses are subject to flood risks, many still are affected by erosion.

FIGURE 5.1 The bluff below this house in South Shore of Nantucket eroded away, causing the house to pitch forward towards the ocean.

(Photo by Stephen P. Leatherman, 1996)

This process is illustrated in Figure 5.2. The cross section of a "stable" bluff is shown in Figure 5.2(a) from the water's edge to several hundred feet inland. In Figure 5.2(b), the same cross section is shown during a storm or higher than average lake level, with the base (or toe) of the bluff being eroded away by waves. The top of the bluff eventually becomes unstable as erosion undercuts the bluff. Figure 5.2(c) depicts the new profile after the bluff stabilizes, with the edge of the bluff further inland than before.

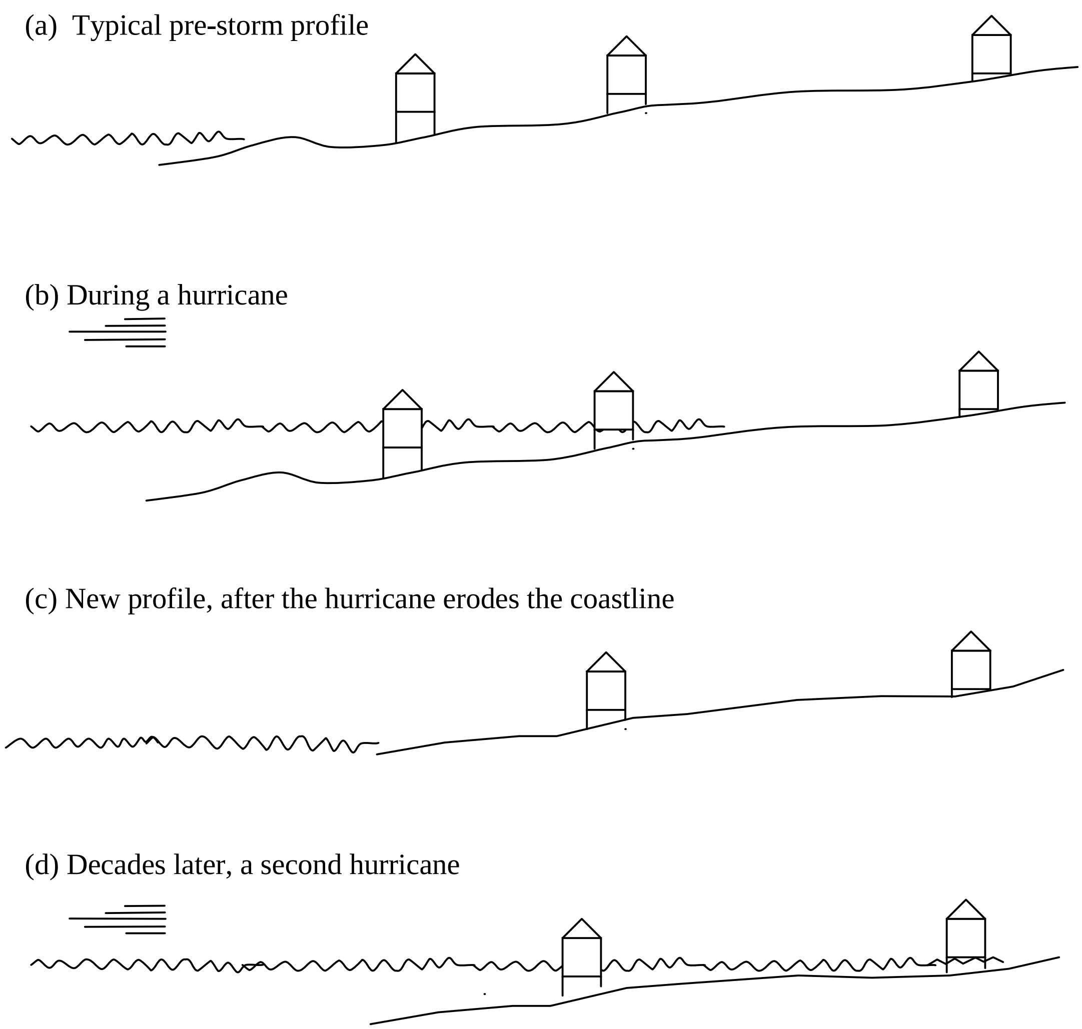
FIGURE 5.2 Bluff erosion on a typical shoreline progresses in several stages. A stable bluff is depicted in (a); the same bluff during a storm or higher than average lake levels is shown in (b). The new bluff profile is shown in (c).



In contrast to the bluffs along the Pacific and Great Lakes coasts, the Atlantic and Gulf coasts typically have low-lying shorelines and are subject to different flooding and erosion processes. Coastal V-zones that are susceptible to erosion face greater risks of damage to structures than do similar regions that are not eroding. Figure 5.3 displays these processes as a sequence through time. Figure 5.3(a) illustrates a cross section of the coastline from the ocean's edge inland several hundred feet. In Figure 5.3(b), the same cross section is shown during a hurricane, with the ocean waves inundating and damaging several houses. If the storm also erodes the coastline, then the profile might look like Figure 5.3(c), in which the house that was closest to the ocean has been destroyed and the remaining houses are now closer to the ocean. Figure 5.3(d) depicts a second storm of the same size as the first hitting the coast several decades later.

Figure 5.3(d) differs in two important ways from Figure 5.3(b). First, because the coastline has eroded (50 to 100 ft over 30 years is fairly common for the Atlantic and Gulf coasts), storm wave heights at each house now are somewhat further inland and higher than they were before and, therefore, are capable of causing greater damage. Second, some of the houses that were not previously within the high-hazard V-zone now are located there. When built, these houses were in what the Federal Emergency Management Agency (FEMA) classifies as an A-zone (i.e., subject to some flooding but likely not with waves of a velocity that can, for example, damage a wall). Now, because of erosion, these houses are subject to the bigger and higher velocity waves that they were not designed to withstand.

FIGURE 5.3 A low-lying coastline subject to storms and erosion can change dramatically over time. A typical pre-storm profile is shown in (a); the same area during a hurricane is depicted in (b). The new profile after the hurricane has eroded the coastline is shown in (c). Decades later, a second hurricane hits the area, as shown in (d).



There are four risks to be concerned about in these low-lying coastal areas:

1. **Flood damage.** Waves and storm surge from a coastal storm of sufficient magnitude can destroy a house (see Figure 5.4). One key determinant of the magnitude of the risk is how the height of the first floor of a house compares to the expected height of waves generated by a storm of a magnitude that has a 1 percent chance of occurring in any given year. Engineering studies by FEMA and the U.S. Army Corps of Engineers (USACE) have concluded that a wave 3 ft above the height of the first floor of a house will have sufficient force to cause damage equal to half the value of the house.

2. **Direct erosion damage.** If a storm is of sufficient magnitude to erode the coast to a position further inland, then houses in the way will be damaged. Some may be left standing, but they will not likely be habitable anymore (or might be condemned for being in public waters).

3. **Higher wave heights.** Once the coastline has shifted inland, flood elevations for the same magnitude storm will be farther inland and higher, and thus can cause more damage.

4. **Higher and more powerful waves in areas not previously subjected to high velocity waves.** Houses that were constructed in lower risk A-zones with less-stringent building codes can be subjected to waves of V-zone intensity.

FIGURE 5.4 Storm surge has destroyed the lowest floor of this house in Buxton, NC .

(Photo by Stephen P. Leatherman, 1974)

FORECASTS OF FLOOD AND EROSION-RELATED DAMAGE

It is possible to model quantitatively the flood and erosion processes listed above, recognizing that it is still a simplification of a much more complex problem. In this section, flood and erosion damages are projected for the Atlantic, Gulf, Great Lakes, and Pacific shorelines of the United States. The procedures used to estimate projected damages are explained in Box 5.1 and Appendix D. As part of this study, FEMA provided The Heinz Center with maps for 27 counties along all four coastlines of the United States. The maps included projections of how the coastline may move inland because of erosion and, where applicable, both expected flood heights from a 1 percent chance ("100-year") storm *today* and 60 years from today.

The maps of today's expected flood heights are those used by local governments within these counties to enforce building codes, by FEMA and insurance agents to set flood insurance rates, by home builders to design houses, and by the general public to understand flood risks when purchasing their homes. These maps are based on results from computer models that generate storm wave profiles from detailed field survey information, wave heights from historic storms, and other data from similar sources.

The projections for 60 years from today were prepared by coastal scientists and engineers in each state, who used historical shoreline changes to determine a long-term average rate of erosion (Leatherman, 1983; Crowell et al., 1999). An example of a 60-year EHA map is shown in Figure 5.5. Future storm wave profiles were estimated with a much simpler procedure. Although several states and communities have prepared similar maps portraying the risks from erosion, definition of the erosion hazard area varies by state, and for many communities, no maps are available at all. The data and procedures used to generate the 60-year shoreline position forecasts are described in more detail in Appendix B.

The Heinz Center hired teams of surveyors to measure the exact location and height of (and collect other information on) about 10,000 houses within about 500 ft of the shoreline in 18 of the 27 counties. Combining the two sets of information, along with the previously mentioned structural damage relationships developed by FEMA and the USACE, The Heinz Center was able to estimate the magnitude of coastal risks faced by these structures today and several decades hence.

BOX 5.1 Estimating Damage to Structures

This chapter presents estimates of the expected damage from flooding and erosion over the next sixty years in Atlantic, Gulf, Pacific, and Great Lakes coast communities. These estimates rely on three data sources: 1) field measurements of about 10,000 structures, 2) projections of shoreline movement based on maps of shoreline position over the past 50 to 100 years, and 3) maps of expected storm wave heights. Damage was calculated structure by structure, then summed by community across three progressively narrower classifications: 1) within 500 feet of the shore, 2) within the V-zone, and 3) within the 60-year erosion hazard area.

These estimates present "snapshots" of expected damages over the next six decades to structures that exist today. Structures are considered "destroyed" after they move seaward of the shoreline, which is typically defined in this study by a vegetation line or front edge of a dune or bluff. A structure is not included in future damages once it is destroyed. The estimates shown in tables 5.1 to 5.4 are for three decades from today and, again, do not include future construction. The estimates of damages are expressed as the annual dollar value of losses per $100 of value. For example, suppose a $100,000 house experiences $30,000 worth of damage in a big storm. In reality, such damage occurs only rarely, on the time scale of decades rather than years. If such damage is expected to occur once every 30 years, its annual expected damage is $1 per year, per $100 of house value.

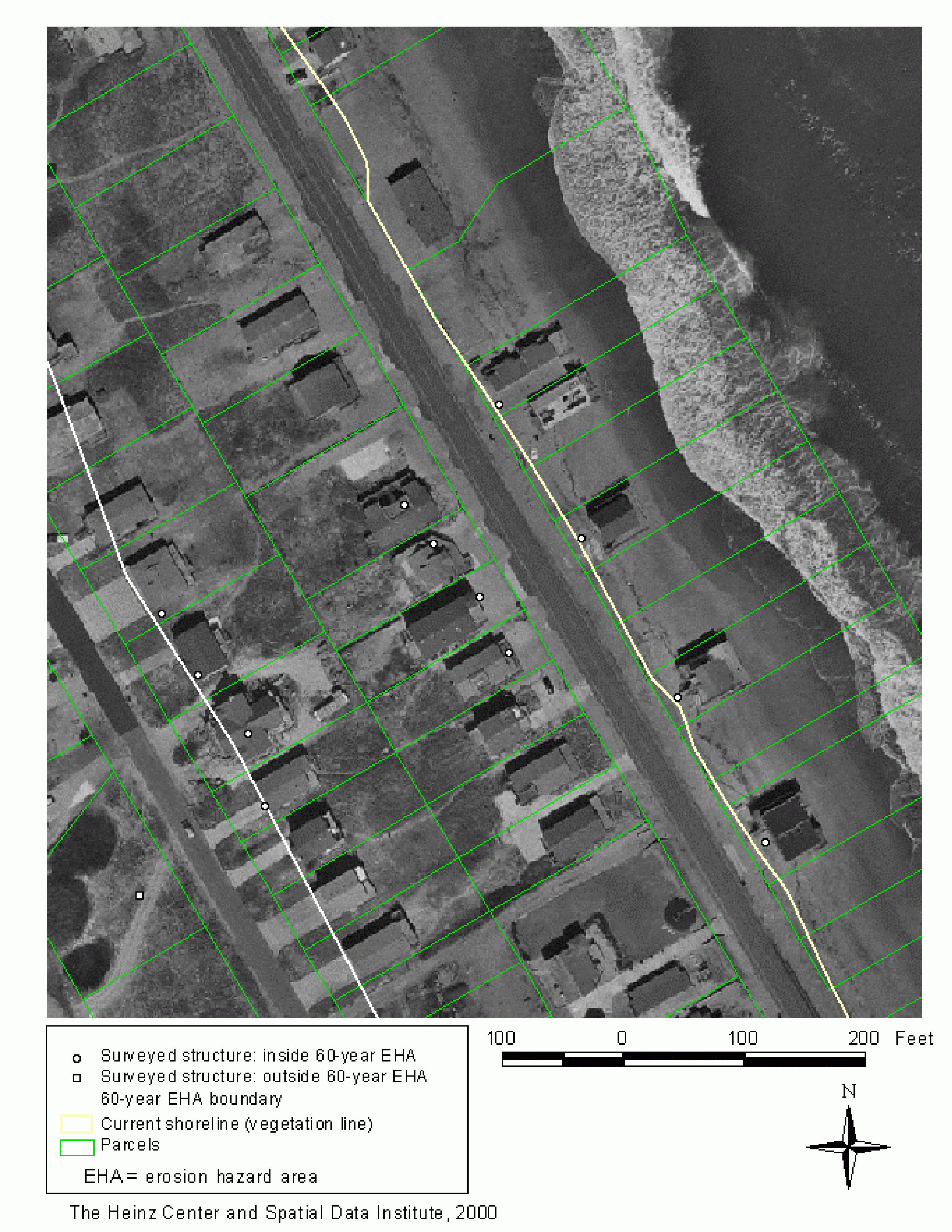
The expected damages reflect three types of risks on eroding shores. One risk is direct flood damage. Our estimates were developed using a damage model developed by FEMA and the US Army Corps of Engineers which calculates expected damage as a function of the elevation of the structure and the expected flood height (Base Flood Elevation).

A second type of risk is increased flood damage caused by inland migration of the shoreline. As the shoreline moves inland, the base flood elevation rises, and structures previously located outside the V-zone may now be subject to wave attack. We estimated the increased damage caused by rising flood heights by taking the difference of future flood damage and current flood damage. We also identified which structures are expected to switch from the A-zone to the more risky V-zone within a given decade, and recalculated flood damage.

The third type of risk is direct erosion damage. As the shoreline moves inland, both the land and structure will eventually be eroded away, to the point at which rebuilding is impossible. The method used to estimate this loss is simple. In the decade in which erosion loss occurs, total damage is assigned for that structure. The decade of loss is determined using the distance of the structure (obtained by GPS field measurements) from the erosion reference feature and the erosion rate. Within the decade in which erosion loss occurs, expected flood damage over the decade is subtracted to avoid double-counting of flood and erosion loss. In reality, however, it is almost impossible to discern whether the cause of loss was erosion or flooding.

On the Atlantic and Gulf, the total expected damage to structures (not including wind) is the sum of 1) direct flood damage; 2) increased flood damage caused by inland migration of the shoreline; and 3) direct erosion damage. Much of the Pacific and Great Lakes shores are only subject to direct erosion damage, because most of the structures there are built up on bluffs.

FIGURE 5.5 This 60-year erosion hazard area map for Dare County, North Carolina, shows current and projected shoreline and property at risk.

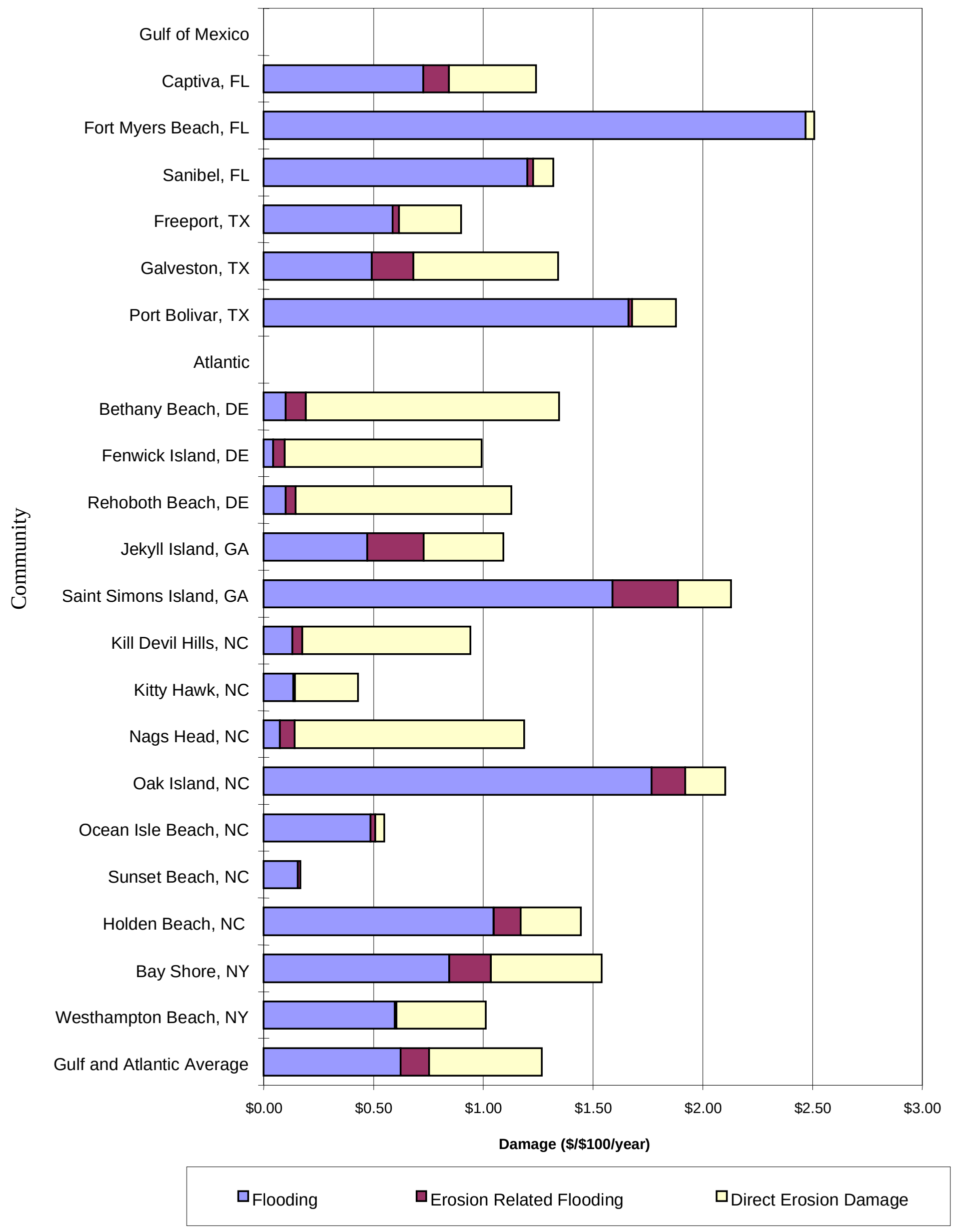


The estimates presented throughout this chapter assume that communities will not respond to erosion by nourishing or hardening their beaches or implementing state or local setbacks regulations. The range of responses historically used by coastal communities are explored in Chapter 4 and Appendix F. Of course, some communities will respond to erosion risks, so the loss estimates presented here will likely be high. It was beyond the scope of this study to determine how many communities would find it cost effective to nourish or harden their beaches.

Figure 5.6 quantifies each individual component (e.g., flooding, erosion-related flooding, and direct erosion damage) of the coastal hazard for about 4,000 houses in 20 communities along the Atlantic and Gulf coasts. These estimates are based upon field survey measurements of structure elevations and current and projected flood heights. The damage measure shown is the expected annual average damage in dollars per $100 of house value. Thus, a V-zone community with a "loss cost" of $1 per year (yr) per $100 of house value will experience, on average, damage of $10 per $100 of house value after 10 years, $20 per $100 of house value after 20 years, and so on. This community-wide measure averages damage across all the houses in only the V-zone—which is typically a subset of the coastal area surveyed in this study. Most of the damage will be concentrated in just a few days when major storms hit. Some houses will be completely destroyed, whereas others will remain untouched.

As shown in Figure 5.6, the communities of Nags Head and Holden Beach, North Carolina, both have average loss costs of $1.00–$1.50/yr per $100 of house value. In Nags Head (located in Dare County), most of the damage forecasted is from direct erosion losses, and the remaining 10 to 20 percent is attributed to intermittent flooding. Almost the opposite is expected in Holden Beach (located in Brunswick County), where about two-thirds of the loss is from flood damage to structures currently in the V-zone. The remaining one-third is mostly from direct erosion losses, but some additional flood damage is expected to structures that were originally in the lower flood risk A-zone but ended up in the V-zone as the shoreline moved inland. The erosion rate at Holden Beach is lower, but houses are built lower relative to the peak floods expected in the area.

FIGURE 5.6 Communities differ in their susceptibility to flooding, erosion-related flooding, and erosion. Estimated loss costs (i.e., projected damage to structures) 30 years from today, averaged across the V-zone, are shown.



Notes: This graph shows estimated damages to structures, by community, thirty years from today. The damage is expressed as $/year per $100 of value and includes flooding, erosion related flooding from landward movement of the shoreline, and direct erosion damage. Longer bars indicate higher projected damage; shorter bars indicate lower projected damage.

Averaged across all the communities in the sample, the following picture emerges, summarized in Table 5.1. Averaged over the V-zone at 30 years from today, the total expected flood and erosion damage is in the range of $1.37/yr per $100 of house value. About $0.67/yr per $100 is erosion-related—$0.52/yr per $100 from direct erosion loss and $0.15/yr per $100 from the inland consequences of an eroding shore. The remaining expected damage of about $0.70/yr per $100 of house value is from intermittent flooding.

Beginning in 1981, FEMA required new or substantially improved houses built in the V-zone to be elevated on pilings to account not only for the expected 100-year flood but also wave impacts. Because of the higher base flood elevation and other requirements—such as dune protection and restrictions on use of fill—these houses experience lower damages than do structures built before the requirements went into effect. Within the "post-1981" class, expected flood damage is $0.32/yr per $100; about half that of all structures.

Table 5.2 presents similar forecasts of flood and erosion damage averaged over successively smaller regions: a 500 ft wide strip of shoreline, the V-zone, and the 60-year EHA. Like the results in Table 5.1, these numbers are for study sites on the Atlantic and Gulf coasts. About 85 percent of V-zone structures and 95 percent of structures in the 60-year EHA are located within 500 ft of the shoreline. Within this narrow strip, expected flood and erosion damage averages $1.00–$1.10/yr per $100 of house value. About $0.60/yr per $100 of house value is expected from today's level of flood damage. Another $0.37/yr per $100 of house value is expected from direct erosion damage, and the remaining $0.10/yr is from increasing erosion-related flood damage.

Table 5.2 also shows expected damage within the 60-year EHA. Expected damage in this region is quite a bit higher than that expected in the V-zone. Total annual expected damage increases to more than $2.00/yr per $100 of house value, primarily because of a near-tripling of direct erosion damage. Note, too, that expected flood damage in this region is somewhat lower than the V-zone damage, illustrating that the houses most susceptible to erosion damage are not limited to those most susceptible to flood damage, and many of the houses most susceptible to flooding are not particularly susceptible to erosion.

As discussed earlier, the situation on the Great Lakes and Pacific coasts is somewhat different. In these regions, eroding bluffs are common. On the Great Lakes, all of the structures along the eroding shores of our sample areas are up on bluffs. Along the Pacific coast, study areas include both sandy beaches and bluffs, sometimes alone but often together.

For example, three of the Pacific Coast sample communities have high flood hazard V-zones, much like those along the Atlantic and Gulf. Two of these communities, Aptos, California, and Otis, Oregon, also have structures within a 60-year EHA; one area, Watsonville, California, does not. The average expected flood damages within these Pacific Coast V-zones are shown in Table 5.3. These values can be compared to those shown for Atlantic and Gulf coast communities in Figure 5.6 and Table 5.1. Flood damages are much higher on the Pacific Coast than the Atlantic and Gulf Coasts because the structures are built lower relative to the peak flood elevation. Another difference between the Pacific Coast communities and the typical Atlantic and Gulf community is that they also contain structures susceptible to erosion that are up on bluffs. Table 5.3 also shows the average expected erosion damage to structures built on bluffs. Estimates of average expected erosion damage in the Pacific Coast V-zones could not be reliably determined because many of the Pacific Coast maps provided to The Heinz Center included information on rates of erosion of the bluffs, but not the beach.

Although the data are sparse for the Great Lakes, some counties (e.g., along the Wisconsin shoreline) have very low percentages of structures within EHAs whereas others have percentages comparable to those observed on the Atlantic and Gulf coasts. Because of a lack of representative measurements across these varying lake shoreline environments, Table 5.4 shows a range of estimates of expected annual erosion damage in the Great Lakes, rather than an average.

Figure 5.7 displays the percentage of structures susceptible to long-term erosion within a strip 500 ft wide along the shore in 16 counties. As is evident, there is a fair degree of variability within all regions. The percentages of structures within 500 ft of the shore are greater along the Atlantic, Gulf, and probably Great Lakes shorelines than along the Pacific. The following section, extrapolating results nationwide, presents regional estimates of expected flood and erosion losses in all four regions.

TABLE 5.1 Projections of Flood and Erosion Damage for Typical Communities on the Atlantic and Gulf of Mexico Coasts: V-zone Structures [a]

Type of Damage	All Structures	Post-1981 Structures Only
Flood damage expected from today’s level of flooding	$0.70	$0.32
Increase in erosion-related flood damage inland	$0.15	$0.06
Direct erosion damage	$0.52	$0.45
Total damage	$1.37	$0.84

[a] Expected annual damage to current structures averaged across the entire V-zone, 30 years from today.
Damage is expressed in dollars per year per $100 of house value.

TABLE 5.2 Projections of flood and erosion damages for typical Atlantic and Gulf Coast communities.[a]

Type of Damage	Averaged over 500 feet	Averaged over V-zone	Averaged over 60-year EHA
Flood damage expected from today's level of flooding	$0.60	$0.70	$0.48
Increase in erosion-related flood damage inland	$0.10	$0.15	$0.17
Direct erosion damage	$0.37	$0.52	$1.54
Total damage	$1.07	$1.37	$2.19

[a] Expected annual damage to current structures averaged over 500 feet, V-zone, and 60-year Erosion Hazard Area. Damage in $ per year, per $100 of house value, expected 30 years from today.

TABLE 5.3 Projections of Flood and Erosion Damages[a] for Pacific Coast Communities: V-zones and Bluffs

Type of Damage	Averaged Across the Entire V-zone	Averaged Across 500 feet Inland from Top of Bluff
Flood damage expected from today's level of flooding	$2.56	$0.00
Increase in erosion-related flood damage inland	unknown	N.A.
Direct erosion damage	unknown	$0.10
Total damage	>$2.56	$0.10

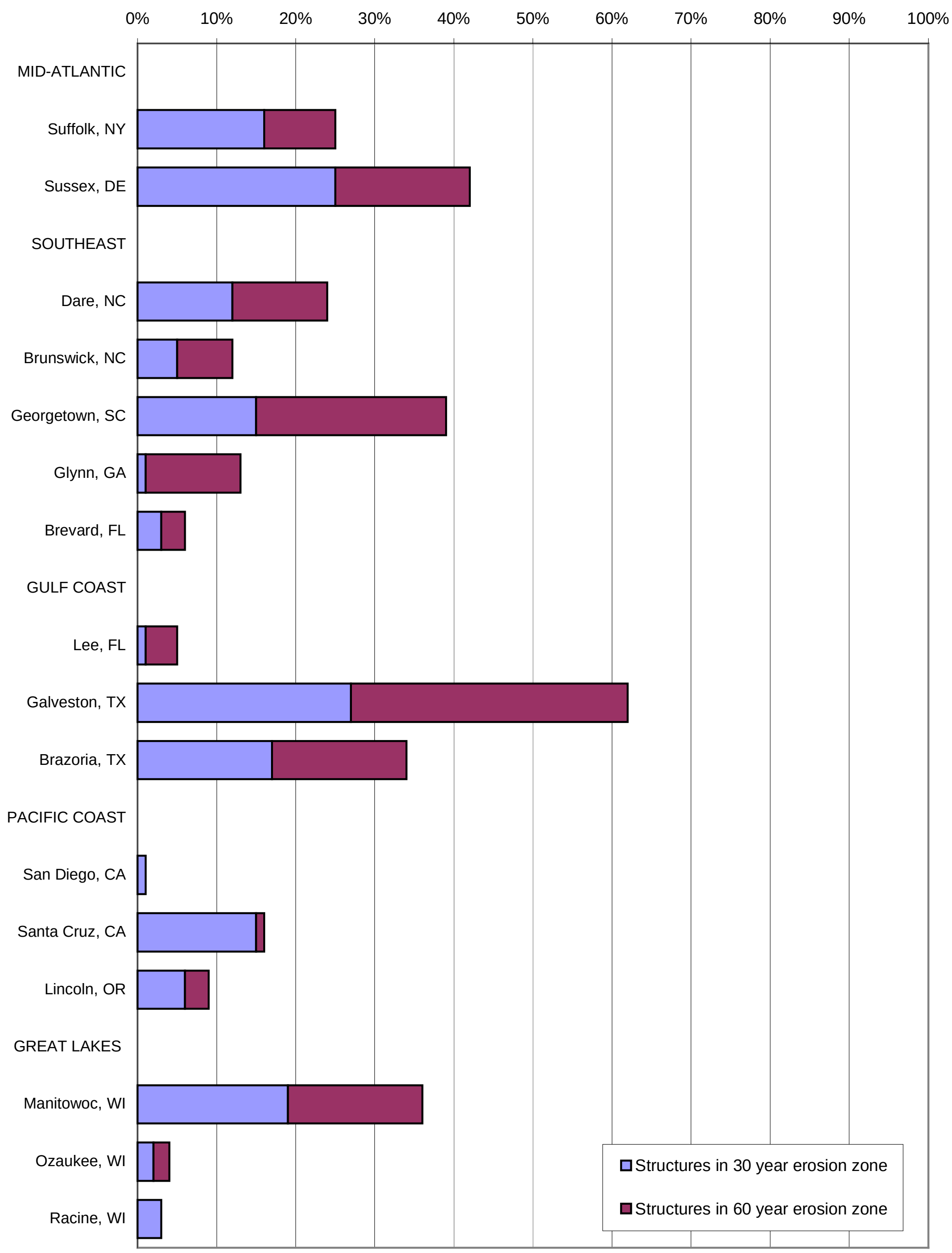
[a] Expected annual damage to current structures averaged over entire V-zone and 500 feet inland from the top of the bluff. Damage in dollars per year, per $100 of house value, expected 30 years from today.

TABLE 5.4 Projections of Flood and Erosion Damages[a] for Great Lakes Communities

Type of Damage	Averaged Across 500 feet Inland from Top of Bluff
Flood damage expected from today's level of flooding	$0.00
Increase in erosion-related flood damage inland	
Direct erosion damage	$0.08–$1.19
Total damage	$0.08 (Wisconsin)–$1.19 (Michigan)

[a] Expected annual damage to current structures averaged over 500 feet inland from the top of the bluff. Damage in dollars per year, per $100 of house value, expected 30 years from today.

FIGURE 5.7 The percentage of structures within 500 feet of shore in the 60-year erosion hazard zone varies by region.



EXTRAPOLATING RESULTS NATIONWIDE

As discussed in Chapter 2, between 300,000 and 350,000 structures are located within 500 ft of the 10,000-mile coastline of the lower 48 states. This estimate is based on housing data from the most detailed publicly available information from the 1990 census.[10] Combining these data with estimates of coastal erosion assembled by Robert Dolan of the University of Virginia, The Heinz Center projected that about 25 percent of these structures—about 85,000 in all—are at risk from erosion over the next 60 years. These estimates do not include structures in the densest areas of large coastal cities, such as New York, Chicago, Los Angeles, and Miami.[11] Much of this shoreline is already heavily protected from erosion through hard shoreline protection structures.

The distribution by region of these susceptible structures is shown in Table 5.5. About 80 percent are found along the Atlantic and Gulf coasts, hence the heavy focus of this chapter on the impacts in these regions. Although these nationwide estimates are based on data and methods that are different from those used for the more detailed analyses of structures in the 18-county sample, there is reasonable agreement between the two.

As shown in Table 5.5, about 53,000 structures along the Atlantic coast, or 30 percent of the structures within 500 ft of the shoreline, are located within the projected 60-year EHA. About one-third of these structures are located in the 0- to 30-year EHA, and two-thirds are located further back in the 30- to 60-year EHA. Another 13,000 structures are located within the 60-year EHA on the Gulf Coast. A higher percentage of structures along the Gulf are in the 30- to 60-year EHA (56 percent) than the 0- to 30-year EHA (44 percent), but the difference is not as great as it is along the Atlantic. On the West Coast, an estimated 4,000 structures, or 5 to 10 percent of the structures within 500 ft of the shore, are within the 60-year EHA. Finally, along the Great Lakes, again about 30% of the structures within 500 ft of the shore are likely within the 60-year EHA, but because of data limitations, our confidence in this estimate is low. Again, in these last two regions, most of these structures are up on bluffs and have not participated in the National Flood Insurance Program (NFIP).

The estimates above are for structures in place today. Forecasting growth over a period of decades in a strip only a few hundred feet wide is virtually impossible. It is possible, however, to tally the number of empty lots present in the 18-county

[10] The most detailed information released by the Bureau of the Census is at the "census block group" level. The Heinz Center extracted housing density from several thousand coastal block groups averaging 4 square miles each on the Atlantic shoreline and 70 square miles each on the Gulf of Mexico shoreline.

[11] Census tracts with housing density greater than 10,000 units per square mile (including roads and open space) are excluded, eliminating structures along about 300 miles of coastline.

sample and use this as an estimate of potential growth. Whether houses are actually built on these empty lots depends on a host of factors, including the possible changes to the NFIP discussed in the next chapter.

The last row in Table 5.5 presents estimates of the number of structures within the 60-year EHA assuming that all empty lots are filled. In the Atlantic Coast counties, about 30 percent of available lots are still available for building. On the Gulf Coast, close to 45 percent may be available for building, whereas on the Pacific coast, only about 10 percent of the lots in the sample are currently empty. It was not possible to count empty lots along the Great Lakes shoreline. If these estimates are indicative of the larger regions, then the total number of structures within the 60-year EHA could grow to more than 120,000 over the next several decades.

TABLE 5.5 Nationwide Estimate of Structures Susceptible to Erosion[a]

Variable	Atlantic Coast	Gulf of Mexico	Pacific Coast	Great Lakes	Total
Length of coastline					
Miles	2,300	2,000	1,600	3,600	9,500
Percentage of total	24%	21%	17%	38%	
Structures within 500 feet of shoreline					
Number	170,000	44,000	66,000	58,000	338,000
Percentage of total	50%	13%	20%	17%	
Structures within 60-year erosion hazard area (EHA)[b]					
Number	53,000	13,000	4,600	16,000	87,000
EHA structures as % of those within 500 feet of shoreline	31%	29%	7%	28%	
Structures within 60-year EHA assuming all open lots are filled					
Number	76,000	22,000	5,200	>16,000[c]	>120,000

[a] All estimates exclude structures in major urban areas. The analysis assumes these structures will be protected from the erosion hazard.
[b] The 60-year EHA is determined by multiplying local erosion rates by 60 years.
[c] Data on open lots not available for Great Lakes
Data may not add to totals because of rounding.

CURRENT AND PROJECTED COST OF EROSION

The value of land and property exposed to erosion risks is substantial. Along the Atlantic Coast, a “typical” house in the 0- to 30-year EHA is worth about $360,000. Typical property values in this EHA are lower along the Gulf of Mexico ($250,000) and Great Lakes ($190,000) but significantly higher on the Pacific Coast ($1.4 million). In the following sections, two complementary measures of the economic impact of erosion are presented: (1) the annual cost of damaged structures and lost land and (2) reduced property values because of perceived risks of erosion.

Annual Cost of Erosion

The annual cost of erosion is the sum of the expected annual damage to structures plus the loss of land. Assuming no additional beach nourishment or structural protection, The Heinz Center estimates that about 1,500 homes and the land on which they are built will be lost to erosion each year. To the owners of these properties, this is a loss of about $530 million per year. Because the amenities offered by a waterfront property are not really lost, but rather are passed to the house behind if a property erodes, the loss to communities is lower. This loss is estimated at about $410 million per year.

Many houses that may be lost to erosion will have flood insurance. Part of their losses will be covered by the NFIP; flood insurance, however, covers damage to structures only, not the loss of land.. For example, within the Atlantic region, the typical policy in V-zones covers up to $150,000 of damage. Thus, assuming that all of these houses carry insurance—and that all of the damage occurs during storms and, therefore, is covered under the NFIP rules—about $200 million per year would be reimbursed to these property owners.

However, not all homeowners buy insurance. Results from the University of Georgia mail survey indicate that roughly half the houses in high erosion areas on the Atlantic and Gulf coasts are covered by insurance, because these houses are also at risk from flooding. However, on the Great Lakes and Pacific coasts, where bluff erosion is the predominant situation, 10 percent or fewer of these houses are insured by the NFIP. Assuming current enrollment rates and that most erosion losses occur during storm periods and are covered, the payout from the NFIP over the next few decades for erosion losses is estimated at about $80 million per year. Table 5.6 presents a nationwide summary of the expected annual economic cost of erosion.

Table 5.6 estimates losses for existing structures only, without accounting for additional growth stemming from the development of vacant lots. Table 5.7 compares estimates of erosion along the Atlantic coast today to the higher losses projected decades into the future. Development density in the 30- to 60-year

EHA is higher than in the 0- to 30-year zone; accordingly, future damage, even with no further growth, also may be higher. The development of vacant lots located within the 60-year EHA also may increase the expected losses. Table 5.7 presents annual costs, assuming that all vacant lots within the 60-year EHA (on average, about 30 percent of total lots) are developed.

TABLE 5.6 Nationwide Estimates of Cost of Erosion: Average Annual Losses to Current Properties Within 60 Year EHA (in Millions of Dollars per Year)

Affected Entity	Atlantic Coast	Gulf of Mexico	Pacific Coast	Great Lakes	Total
Owners[a]	$320	$50	$110	$50	$530
Community[b]	$260	$50	$70	$30	$410
National Flood Insurance Fund[c], assuming 100% enrollment:	$130	$20	$10	$30	$200
National Flood Insurance Fund[c], assuming current enrollment	$70	$10	$1	$2	$80

[a] Loss of structure and land.
[b] Loss of structure and land, not including the "amenity value" of the oceanfront, which is transferred from owner to owner.
[c] Payments from the National Flood Insurance Fund are for damage to structures and contents only.
Data may not add to totals because of rounding.

TABLE 5.7 Estimates of Cost of Erosion Along the Atlantic Coast: Variation in Average Annual Losses Through Time (in Millions of Dollars per Year)

Affected Entity	Within 30 Year EHA	30 to 60 Years from Today (Existing Structures Only)	30 to 60 Years from Today (Assuming All Lots Filled)[a]
Owners[b]	$200	$440	$630
Community[c]	$160	$360	$510
National Flood Insurance Fund[d], assuming 100% enrollment	$80	$180	$260
National Flood Insurance Fund[d], assuming current enrollment	$40	$90	$130

[a] Vacant lots are, on average, about 30 percent of total lots.
[b] Loss of structure and land.
[c] Loss of structure and land, not including the "amenity value" of the oceanfront, which is transferred from owner to owner.
[d] Payments from the National Flood Insurance Fund are for damage to structures and contents only.
Data may not add to totals because of rounding.

The projections of expected erosion losses have a fair degree of uncertainty; actual losses may be higher or lower than the losses shown in Table 5.6 and Table 5.7. The estimates of expected losses are particularly sensitive to the average annual erosion rate and growth rates. These estimates assume that the forecasted rates of shoreline change will remain constant in the future. Several factors, however, may cause erosion losses to depart from the long-term average. Factors that could reduce erosion losses include increased use of such mitigation measures as seawalls, armoring, beach nourishment as well as fewer severe storm events. Factors that could increase erosion losses include decreased beach nourishment and increased development density and housing values within EHAs.

Effect of Erosion on Current Property Values

Clearly, once erosion destroys a house and claims enough of the land that rebuilding on the lot is impossible, the owner has lost the full value of the property. As shown in Table 5.5, an estimated 53,000 structures along the Atlantic Coast fall within the zone likely to be lost to erosion over the next 60 years. But the loss in value is not an "all or nothing" proposition. Houses close to a rapidly eroding shore are worth less than otherwise identical houses that are close to shores that are relatively stable.

To test this assertion, The Heinz Center's research collaborators at the University of Georgia examined field measurements and mail survey responses for about 1,200 structures in seven Atlantic Coast counties. These were houses for which the information was complete enough to enable sales price to be linked to a series of characteristics, including house size and age; lot size; number of bedrooms; wood or brick construction; distance from, and erosion rate of, the nearest shore; elevation above expected flood heights; and whether the beach is nourished or armored. The statistical procedure used is explained in Box 5.2. A more complete explanation and presentation of results is included in Appendix D

The University of Georgia researchers conclude that there is a statistically significant correlation between house price and the number of years until the nearest shore is likely to erode and reach the house. This relationship, for a typical waterfront property 100 ft from the water, is shown in Figure 5.8. Along the Atlantic Coast, a house that is 100 ft from the shoreline, but expected to reach the water in 50 years, is estimated to be worth about 90 percent of an identical house also located 100 ft from the shoreline, but expected to reach the water in 200 years. Similarly, a house estimated to be within 10 to 20 years of an eroding shore is worth 80 percent of one located 200 years away. This varies somewhat from region to region, but the Atlantic Coast results are typical.

BOX 5.2 Estimating the Effect of Erosion on Property Value

The effect of erosion on property value was estimated by analyzing the primary components of coastal property values (e.g., house size, ocean view, neighborhood, etc.) and then comparing typical properties in eroding and non-eroding areas. The statistical technique used to estimate these relationships was regression analysis—a procedure used to understand complex relationships that are not easy to spot upon first inspection. This type of analysis is used not only to estimate such relationships, but also to predict how certain changes (such as distance away from the shoreline) may lead to other changes (such as property value). "Hedonic price analysis" is the specific form of regression analysis used in this research (see Freeman, 1993).

Hedonic price analysis uses market sales prices of houses in a given area as a dependent variable (i.e., that which is to be explained). Many independent variables (i.e., factors that affect the price) can be included, such as number of bedrooms and square footage. These are structural characteristics that should have an effect on the price of a house. Neighborhood characteristics are usually included as well (such as distance from an urban center). Both types of independent variables should affect the value (and therefore sales price) of a house. Environmental factors can also affect the sales price (see MacDonald, 1987). For research on coastal hazards, such factors include whether the property is ocean or lakefront; the house's elevation above the forecast height of a 100-year flood; and the distance from, and erosion rate of, the shore. Hedonic price analysis allows researchers to estimate the relative contribution of the independent variables to the house sales price, which, in turn, implies the value of those factors to consumers.

Once such an analysis is conducted, the model can also can be used to predict how housing prices will change given a change in one of the independent variables. For example, if erosion rates increased by 1 foot per year, how would housing prices be expected to change? Or, if beaches were nourished, what would happen to housing prices?

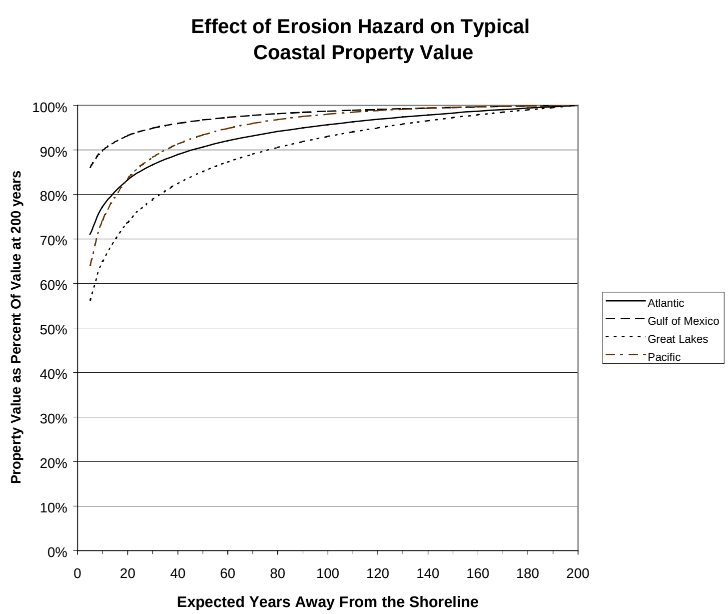
Table 5.8 includes model estimates that provide some insight into current losses in property value as a result of erosion. For this analysis, the 60-year EHA was divided into two zones: the shoreward side, up to 30 years from the coast; and the somewhat less risky 30- to 60-year zone (that is, the landward half of the 60-year EHA). Along the Atlantic Coast, a "typical" house in The Heinz Center sample is 28 years old and has four bedrooms and 2000 ft^2 of floor space on a 14,500 ft^2 lot. About half of the properties within 500 ft of the shoreline are on the oceanfront. Such a house located in a non-eroding area is worth between $420,000 and $440,000. However, the homes in the landward half of the 60-year EHA are estimated to be worth $20,000 to 37,000 less today as a result of erosion. Those in the shoreward half of the 60-year EHA are worth about $61,000 to 80,000 less today as a result of erosion. The difference in property value reflects the buyers' perceptions of the erosion risks and, subsequently, reduced offers for eroding properties.

By adding up these figures across the 53,000 structures currently inside the 60-year EHA on the Atlantic Coast, The Heinz Center estimates a current loss in property value to the owners of these homes of approximately $1.7 to 2.7 billion. This estimate represents consumers' judgment, as revealed through market prices, of how much less these houses are worth as a result of the risks posed by coastal erosion. Similar estimates of current loss in property value are shown for the Gulf of Mexico, Great Lakes, and Pacific Coast regions.

Table 5.9 presents a summary of the economic impacts of erosion nationwide. The estimated loss in property values for the 87,000 houses within the 60-year EHA nationwide is $3.3 to 4.8 billion. Again, this is how much less these houses are worth today in comparison to identical houses in areas that are eroding slowly or not at all. If houses are built on all the empty lots within the 60-year EHA, then the loss in property value might total about $4.5 to 6.5 billion.

The present value of 60 years of such losses at an interest rate of 5 percent per year is about $10 billion per year, somewhat higher than the decline in house value estimated above, but quite close. "Net present value" is the total value today of a series of future payments. Thus $10 billion dollars in the bank today would cover payments of about $500 million per year for 60 years, at an interest rate of 5 percent per year.

FIGURE 5.8 Coastal erosion reduces property values in the United States, albeit more quickly in some regions than in others.



Note: Results for the Gulf of Mexico are not statistically significant.

TABLE 5.8 Loss in Property Value Caused by Erosion[a]

	Loss in Property Value Today (in Dollars)			
Location	Atlantic Coast	Gulf of Mexico Coast	Great Lakes Shorelines	Pacific Coast
0- to 30-year EHA[b]	$61,000–80,000	$17,000–20,000	$48,000–66,000	$313,000–347,000
30- to 60-year EHA	$20,000–37,000	$7,000–11,000	$24,000–43,000	$69,000–95,000
Typical property value[c]	$410,000	$270,000	$260,000	$1.3 million

[a] This table estimates how much less properties are worth *today* as a result of the risks posed by coastal erosion. Property values are compared to a structure located 100 years from the shoreline (lower bound) and 200 years from the shoreline (upper bound).
[b] Erosion hazard area.
[c] Typical property values within 250 feet of the coastline (including both eroding and non-eroding areas)

TABLE 5.9 Estimated Economic Impacts of Erosion in 60-Year Erosion Hazard Areas Nationwide (in Millions of Dollars)

Type of Loss	Atlantic Coast	Gulf Coast	Great Lakes Shorelines	Pacific Coast	Total
Loss in property value	$1,700–2,700	$100–200	$600–900	$900–1,000	$3,300–4,800
Loss in property value, assuming all empty lots are filled	$2,500–3,800	$200–300	$800–1,100	$1000–1,200	$4,500–6,500

HAZARDS AND COASTAL DEVELOPMENT DENSITY

In addition to examining the effect of coastal hazards on property prices, The Heinz Center was interested in determining whether there is an effect on development. A team of researchers at the George Washington University (GW) reconstructed 35-year development histories of 120 blocks of homes within seven of the counties inventoried. Four of the counties were on the Atlantic coast, two were on the Gulf of Mexico, and one on the Pacific coast.

The researchers used statistical regression methods to examine whether the amount of land developed in each block was related to the risk of erosion (whether it was in the front half of a 60-year EHA, the back half, or outside of the EHA); the risk of flooding (whether it was in a V-zone or not); as well as other factors, such as whether it was a waterfront block. The GW team also explored whether the availability of flood insurance under the NFIP affected the density of development.

Just as erosion appears to have an effect on property prices, so, too, does it seem to affect the density of development. For blocks within the front half of the 60-year EHA (that is, the ocean side, or the 0- to 30-year zone), blocks closer to the ocean in years had a lower development density. A difference of 15 years—half the width closer to the ocean—reduced development density by about 10 percent. In the back half of the EHA (the 30- to 60-year zone), the effect of location within the zone was small and not statistically significant. Outside the 60-year EHA, development was denser in blocks closer to the ocean in years. This finding was significant in one model specification but not in another; the results may merely be indicating that, outside of the EHA, development density is more rapid in areas closer to the ocean.

The GW team also found that flood risk affects development density. In the absence of insurance and other programs to reduce flood risk, development density would be about 25 percent lower in V-zones than in areas less susceptible to damage from coastal flooding. However, the researchers also found a correlation with the availability of flood insurance (and the programmatic changes that occurred along with it). During the early phases of the NFIP in the late 1960s and early 1970s (i.e., the "emergency phase" prior to the development of Flood Insurance Rate Maps [FIRMs]), development density was about 15 percent lower in areas now classified as V-zones than in areas less susceptible to flooding. After the release of the FIRMs and associated building code changes, beginning in the mid-1970s and continuing through the early 1980s, development density was about 10 percent lower in V-zones. Thus, it appears that although development density is still lower than average in areas identified by the NFIP as high-risk flood areas, the difference is less than it was before the program. The implications of these findings for bluff and cliff areas, where the NFIP currently does not pay for erosion losses, are explored in the next chapter.

Although development density has increased, total flood damage is lower than it would have been if the program had never been enacted (or if insurance availability was restricted in coastal areas), because of the program's floodplain management and building code requirements (described in chapter 3). Structures built after the program's V-zone building requirements went into effect in 1981 are expected to sustain significantly less flood damage than older structures built prior to the NFIP. Figure 5.9(a) and Figure 5.9(b) show structures built prior to and after the NFIP building requirements went into effect.

FIGURE 5.9 Structures built prior to the implementation of National Flood Insurance Program (NFIP) building requirements and State setback regulations differ significantly from those built afterwards, as shown by these examples in Dare County, North Carolina. The older structure, shown in (a), is built on piers and located in the V-zone. It is not designed to withstand the high-velocity forces associated with wave attack. The newer structure, shown in (b), is elevated on pilings above the base flood elevation in accordance with NFIP requirements. It is located in the lower risk A-zone. The lower floor, used for parking and storage, is enclosed by open wood lattice-work designed to keep the structure free of obstruction in the event of a flood. Both structures are within the 60-year erosion hazard area, but the newer structure is located further back from the shoreline (127 versus 12 feet).

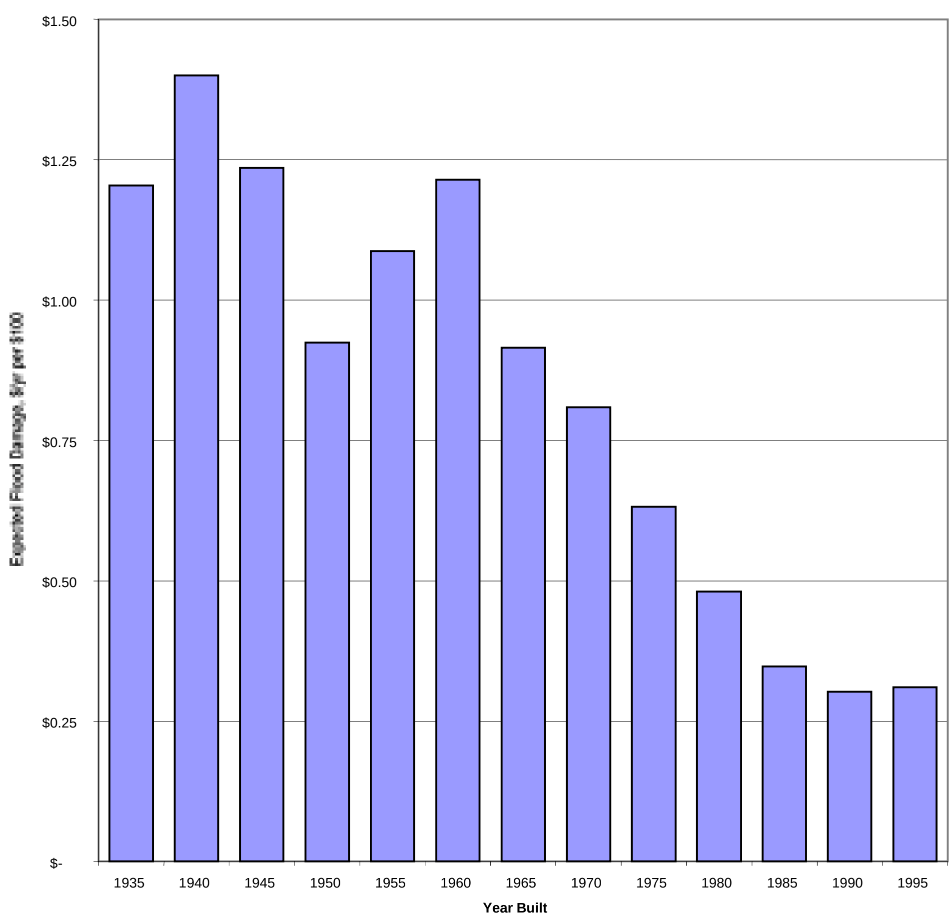
(a)

(b)

SOURCE: The Heinz Center

Figure 5.10 shows expected flood damage to structures by year built on the Atlantic and Gulf coasts. Prior to 1970, expected damage from flooding within coastal V-zones was $0.90–$1.25/yr per $100 of house value. As the program was phased in after 1970 (communities in the sample adopted NFIP building codes beginning in 1972 and continuing through 1985), expected flood damage to new structures dropped. By 1985, expected flood damage to new structures had dropped to $0.30–$0.35/yr per $100 of house value. These estimates were determined by averaging expected flood damage by year built in 5-year increments. Building dates were obtained from county assessment records and flood damage is calculated at expected flood heights today.

FIGURE 5.10 Expected flood damage to new structures has been dropping over time on the Atlantic and Gulf coasts.



The decrease in damage attributable to improved building practices as a result of the program has been considerably greater than the increase in development density. Overall, the damage to structures built after 1981 lower than it would have been if development had occurred at the lower densities, but at higher expected flood and erosion damage, that would have occurred if the program had never been adopted. This is illustrated in Tables 5.10 and 5.11.

The first column of Table 5.10 displays development density per unit area. Development density observed in The Heinz Center study sites in 1980 (i.e., houses built 1980 and earlier) is scaled to $100 per unit area. By 1997, density had increased by about 60 percent to $161 dollars per unit area. According to the results of the GW researchers statistical model, development density might have been closer to $153 per unit area by 1997 if the NFIP had not been adopted, about 5 percent lower than the density observed in 1997. The second column displays the changes in expected annual flood and erosion damage per $100 of house value. The expected annual flood and erosion damage to V-zone structures built 1981 or earlier in our Atlantic and Gulf Coast samples is $1.32/yr per $100 of house values. By 1997, expected damage to structures had declined to $1.14/yr per $100 of house value, a drop of about 14 percent. Again, much of this decline is the result of improved building standards and floodplain management for which the NFIP was in large part responsible.

The last column in Table 5.10 displays expected damage per area, which depends on both development density and the susceptibility of each structure to damage. Expected damage per area in 1980 was $1.32 per unit area. By 1997, this has grown to $1.83 per unit area. If the NFIP had not been adopted, the rate of growth might have been somewhat lower, but the expected damage per structure higher. Overall, the results of this analysis indicate that damage from flood and erosion is about 10 percent lower today than it would have been if the NFIP had not been enacted.

Table 5.11 presents similar information, but isolates the effect on houses built after 1980, that is the effect on houses built after the program matured into its current form. The GW researchers statistical model estimates that the density of structures built within the V-zone after 1981 may be 15 percent higher than it would have been if the NFIP had not been adopted. However, the expected average annual flood and erosion damage to these structures dropped close to 35 percent. Thus, overall, the damage to V-zone structures built after 1981 is between 25 and 30 percent lower than it would have been if development had occurred at the lower densities, but higher expected damage, that would have occurred absent the NFIP.

The program's environmental impacts could not be ascertained. Development density did increase under the program, so it is plausible that environmental damage increased as well. However, other aspects of the program, such as encouragement for dune protection, may have mitigated this trend. The Heinz Center hopes to explore this question in a future study.

TABLE 5.10 Effect of National Flood Insurance Program Requirements on Development Value and Damage in High Hazard Flood Areas

	Time Period	Development Value per Area	Annual Damage per $100 in House Value	Annual Damage per Area
Observed:	1980	$100	$1.32	$1.32
Observed:	1997	$161	$1.14	$1.83
Hypothetical:	1997, no NFIP	$153	$1.32	$2.02
Observed:	% change 1981-1997, with NFIP	+61%	-14%	+39%
Hypothetical:	% change 1981-1997, no NFIP	+53%	0%	+53%
	Difference with NFIP, 1997	+5%	-14%	-9%

TABLE 5.11 Effect of National Flood Insurance Program Requirements on Development Value and Damage in High Hazard Flood Areas: Effect on Construction After 1980

	Time Period	Development Value per Area	Annual Damage per $100 in House Value	Annual Damage per Area
Observed:	Pre-1981 construction	$100	$1.32	$1.32
Observed:	Construction built 1981-1997	$61	$0.84	$0.51
Hypothetical:	Construction 1981-1997, no NFIP	$53	$1.32	$0.70
	Difference with NFIP, 1981-1997 only	+15%	-36%	-27%

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FEDERAL POLICY OPTIONS AND RECOMMENDATIONS

The National Flood Insurance Program (NFIP) was adopted to address the risks due to flooding but not the closely related risks from coastal erosion which were poorly understood at the time. This chapter presents a series of policy options to better incorporate coastal erosion into the NFIP, examining the advantages and disadvantages of each one based on the analyses conducted by The Heinz Center and its consultants. To provide a context for the analysis, the chapter opens with a description of the “building blocks” of the NFIP—information, insurance, and mitigation—and a summary of how the public responds to them.

BUILDING BLOCKS: INFORMATION, INSURANCE, AND MITIGATION

To understand how the NFIP combines information, insurance, and mitigation, it is useful to recall the intent of the U.S. Congress in creating the program. The NFIP was enacted to limit increasing expenditures on flood control and disaster relief, provide a pre-funded mechanism to indemnify more fully the victims of flood-related disasters, and get communities to adopt and enforce floodplain management measures to reduce future flood damage. However, the 1968 Act and 1970 amendment that created the emergency program—which offered reasonably priced flood insurance in exchange for voluntary state and local government actions to enforce floodplain management measures—did not work as well as intended. By mid-1973, only about 2,000 communities had joined the NFIP and fewer than 300,000 property owners had purchased flood insurance. Beginning with statutory changes in 1973, Congress amended the program several times to correct its shortfalls and further its original goals. Today, approximately 20,000 communities in all states and jurisdictions have joined the NFIP and 4.1 million property owners have purchased flood insurance.

The first component of the program is to identify the risk and get the information to the public, lenders, insurance and real estate agents, and state and local governments. To do this, the NFIP published Flood Insurance Rate Maps (FIRMs) covering approximately 165,000 square miles (mi) of flood-prone areas.

The second component is to assure the purchase of sufficient insurance and the enrollment of adequate numbers of communities and individuals to curtail the expansion of federal disaster relief and flood control programs. Insurance has been made readily available through the re-involvement of the insurance industry under the “write your own” (WYO) program. Under this program, the insurance purchaser and insurance agent have a wide selection of insurers from which to choose. The WYO program has proven to be very effective in providing prompt claims adjustments and payments after a catastrophic flood or hurricane. Changes in the National Flood Insurance Reform Act of 1994 have increased enrollment and will likely continue to do so.

The third component is to encourage wise use of the floodplain. Most states have delegated their land-use authorities to local governments (though a few, such as South Carolina and California require state permits.) Therefore, the NFIP requires communities to adopt floodplain management requirements, including performance standards for new construction and substantial improvements to existing buildings located in special flood hazard areas on the FIRMs. The increased insurance rates and restricted coverage offered for noncompliant buildings are deterrents to this type of construction. Conversely, the reduced rates offered for compliant buildings serve as incentives for communities and builders to exceed the NFIP floodplain management requirements. In addition, post-disaster property purchase and relocation projects are encouraged. Through the use of NFIP funds, other Federal Emergency Management Agency (FEMA) mitigation and prevention funds, and funds from other government sources, more than 20,000 pieces of property have been removed from primarily riverine floodplains. Virtually all of these areas are now open land space with no buildings.

Attitudes Towards Natural Hazards and Mitigation and Insurance Purchase Decisions

The reduction or distribution of erosion losses through mitigation or insurance requires participation by property owners, coastal communities, and financial institutions. However, experience with natural disasters shows that many individuals underestimate the risk they face. Consequently, they tend to not invest adequately in either insurance or mitigation measures that could lower their risk.

Studies of mitigation adoption in hazard-prone areas of the United States have concluded that individuals are not willing to invest voluntarily in mitigation even if they or their friends and neighbors sustained heavy damage in recent disasters (Kunreuther, 1997). For example, after Hurricane Andrew in Florida in 1992, most residents in hurricane-prone areas apparently did not make cost-effective improvements to existing dwellings that could reduce the damage from another storm. A July 1994 telephone survey of 1,241 residents in six hurricane-prone areas along the Atlantic and Gulf coasts revealed that 62 percent had not installed hurricane shutters, used laminated glass in windows, installed roof bracing, and/or made sure that side walls were bolted to the foundation either before or after Hurricane Andrew (Insurance Institute for Property Loss Reduction, 1995).

Likewise, the voluntary purchase of insurance is low. The University of Georgia mail survey to coastal property owners found that 40 percent of the structures in The Heinz Center study sites were covered by flood insurance. Only 9 percent of the homeowners participated voluntarily; the remaining 31 percent had to purchase insurance to be eligible for federally backed mortgages.

Experience with earthquake insurance provides additional insight into perceptions of risk and decisions about whether to purchase insurance. In the case of earthquakes, perceived risk is a major predictor of insurance purchases. In a study by Palm (1990), respondents to a mail survey were asked to estimate the probability of a major earthquake damaging their community or home. The responses consistently distinguished the insured from the uninsured. Those with higher perceived vulnerability to future earthquakes were more likely to buy earthquake insurance than were those who believed that an earthquake was unlikely to affect their home or community.

There appears to be no evidence suggesting that individuals refuse to purchase *property* insurance because they expect to be bailed out by the government should they sustain damage.[12] The only empirical findings on this question, from a survey undertaken more than 20 years ago, suggest just the opposite pattern. Although most uninsured homeowners were aware that the Small Business Administration (SBA) provided aid to victims, they had little knowledge of the terms of the loans, and most did not anticipate turning to the federal government for relief if they sustained damage from a disaster. In fact, the data suggest that most homeowners expect to rely on their own resources or bank loans. Their decisions not to purchase insurance were due primarily to other factors, such as not perceiving the hazard to be a serious problem (Kunreuther et al., 1978).

Policy approaches to minimize damage and alleviate hardships in eroding areas include insurance, land-use regulations, and support for engineered shoreline protection. Insurance, if designed carefully, offers an advantage over other policy approaches in that it plays a dual role. It rewards individuals prior to a disaster (through lower premiums) for locating in safer areas, and it compensates these same individuals after a disaster for any damages sustained. However, for insurance to be effective in both these roles, those at risk must bear a substantial portion of the costs of residing in hazard-prone areas, or else they will have limited economic incentive to take protective actions.

Under the current NFIP, most erosion damage is covered but not separately identified. One option discussed in greater detail below is to impose an erosion surcharge on flood insurance held by those living in eroding areas. Such a surcharge would ensure that those most at risk pay for their potential losses and encourage other individuals, by offering them reduced premiums, to stay out of harm’s way. A second option would combine a surcharge with additional community-based mitigation requirements, to ensure at least a minimal response by individuals who may be underestimating the risks they face.

OVERVIEW OF THE POLICY OPTIONS

The Heinz Center has constructed nine policy options, or packages of options, that the Congress may choose to consider in responding to the coastal erosion risks discussed in the previous chapters. The first five are policy packages that span the full range of possibilities, from maintaining the status quo to combining insurance and mitigation programs similar to the current NFIP but with additional attention to erosion hazards. The packages are meant to be mutually exclusive, that is, only one can be chosen. The remaining four are options that can be used, alone or in combination, to augment any of the policy packages. In

[12] There is evidence, however, that many farmers do not purchase crop insurance because they have been assisted by the federal government following natural disasters, especially drought. Chite (1992) summarizes the government’s willingness to provide disaster assistance even though insurance is available.

brief, the options are as follows:

1. Maintain the status quo (i.e., no change in policy). Nineteen of 30 coastal states currently incorporate erosion risks into the approval process for new construction close to the shoreline. However, information about erosion risks is spotty, and both the information and its usage are inconsistent from state to state. Although the NFIP appears to cover most erosion-related damage in low-lying areas, current insurance rates do not reflect the variation in risk among policyholders.

2. Erosion mapping and dissemination alone. The simplest and least intrusive change would be to direct FEMA to prepare maps displaying the location and extent of areas subject to erosion and make the information widely available. Individuals and localities would be free to use this information as they felt appropriate.

3. Creation of a coastal high hazard zone, including both high flood and erosion zones. The existing high flood hazard "V-zone" could be expanded by FEMA to include areas susceptible to erosion damage over the next several decades. Most, but not all, areas susceptible to erosion are also in V-zones. Insurance rates would be calculated in a similar manner to today's program but would have to be increased.

4. Mandatory erosion surcharge on flood insurance in erosion zones. Many homeowners pay insurance rates far lower than is necessary to cover the risks due to both flooding and erosion. This shortfall will have to be covered by either other NFIP policyholders or the general taxpayer. Congress could direct FEMA to impose an insurance surcharge on current flood policies to cover erosion risks.

5. Erosion surcharge combined with regulatory measures to reduce damages. Under the current NFIP, a condition of the offer of insurance to individuals is the community's adoption of regulations to reduce future damage. The Congress might follow this model and add, for example, land-use restrictions in erosion-prone areas to the list of measures that communities must adopt for residents to remain eligible for combined flood and erosion insurance.

Congress could add any of the four options below to one of the policy packages listed above.

6. Flood-related regulatory changes in erosion zones. Erosion not only causes damage directly, but also, over time, increases the risk from flooding. The likelihood of damage could be lowered somewhat if FEMA directed communities to apply building standards appropriate to the flood conditions expected several decades from now, rather than conditions today.

7. Erosion insurance in bluff areas susceptible to erosion but not flooding. Although houses on bluffs overlooking the Great Lakes and ocean coasts are also subject to erosion damage, homeowners in these areas typically have not purchased flood insurance. The NFIP rules currently provide insurance for some, but not all, erosion-related damage on bluffs. The Congress could direct FEMA to design a program more consistent with the erosion problems in these areas.

8. Relocation assistance and/or land acquisition. Improved building standards have been very successful in lowering flood damages but are unlikely to be as effective for erosion. Relocation of existing structures and land acquisition are mitigation options that can lower erosion damage, but they have not been used extensively because of the high value of coastal property. Congress could instruct FEMA to reconsider these options—and their ancillary environmental benefits—in the context of an expanded insurance program.

9. Shoreline protection measures (nourishment, dune restoration, and hardening shorelines). Along with relocation, these measures are the only options that can reduce damage to existing structures. The federal government currently pays a large share of the costs of nourishing or hardening beaches, measures sometimes used in densely developed areas. If any of the options above are chosen, Congress might wish to examine their implications for shoreline protection policy and vice versa.

Key Questions for Comparing Options

To help sort through these options, The Heinz Center constructed a series of evaluation criteria that Congress may want to consider. These criteria reflect possible goals for changes to the flood program. It is anticipated that each of these goals will be embraced by many members of Congress, but that the priority assigned to each goal will vary. The criteria are as follows:

- Will the public be better informed about the risks of living on the coast?
- Does the change help alleviate economic hardships from erosion damages that do occur?
- Is the program fairer?
  - Will insurance rates more closely reflect risk?
  - Are additional restrictions imposed on property owners?
- Does the change lead to reduced damage to structures?
  - Does it avert damage to structures not yet built?
  - Does it help reduce damage to existing structures?
- Does the change lead to other desirable outcomes, such as environmental benefits or enhanced opportunities for recreation?

- Is the change cost-effective for affected individuals?

Figure 6.1 displays the types of outcomes Congress can expect from each of the options above. These outcomes are summarized below.

Will the public be better informed about the risks of living on the coast?

As previously discussed, when Congress established the NFIP 30 years ago, one of its key goals was to better inform the public of the flood risks they face. The widespread availability of FIRMs has advanced that goal. As shown in chapter 5, however, erosion poses risks today about equal to those posed by flooding along the coast. Options 2 through 7, which depend on the availability of detailed erosion hazard maps prepared by FEMA, all would help better inform the public about the risks of living along the coast.

Does the change help alleviate economic hardships from erosion damages that do occur?

When erosion damages do occur, of the options listed above, only those that involve insurance can help alleviate the economic hardship that such damage entails. Along beach areas, the NFIP appears to reimburse policyholders for most erosion-related damage. Whether options 3 through 5 serve to alleviate more of the economic hardship associated with erosion depends on the details of implementation, as discussed later in the chapter. Altering the conditions for coverage in bluff areas likely will expand enrollment and, thus, enhance the benefits of insurance in these areas.

Is the program fairer?

"Fairness" is, of course, a complex and highly subjective notion. Two aspects are most relevant here. The first is how closely insurance rates reflect the risks to which each policyholder is exposed. Options 4 and 5 include a mandatory erosion surcharge on flood policies in erosion-prone areas to bring insurance rates closer in line with expected damage. Although many government programs do spread the costs beyond those who benefit, there is no compelling reason why this should be the case for erosion but not for flooding.

The second aspect of fairness is most relevant to options 5 and 6—those that include regulatory restrictions. Although regulations such as restrictions on building at the water's edge in the most erosion prone regions can lower property damage and taxpayer costs of disaster assistance, some claim that this approach imposes unfair burdens on property owners. Again, the current NFIP is designed to incorporate local regulatory restrictions. It is a value judgment as to whether and what types of regulations are justified, or whether other approaches (e.g., market mechanisms such as differential insurance under option 4) are preferred.

FIGURE 6.1 The various policy options for addressing coastal erosion are likely to have different outcomes.

Policy Options / **Evaluation Criteria**	Better informs the public of risks they face?	Alleviates economic hardship from erosion?	Makes program fairer?	-- Rates more closely reflect risk?	-- Imposes additional limits on owners?	Lowers damage to structures?	-- Avoids damage to structures not yet built?	-- Helps lower damage to existing structures?	Other benefits, e.g., environmental, recreation?
1. Maintain status quo	■	■		■	■		■	■	■
2. Erosion mapping and dissemination alone	✓						✓ ?		
3. Creation of coastal high hazard zone, including both high flood and erosion risks	✓	?					✓ ?		
4. Mandatory erosion surcharge on flood insurance in erosion zones	✓	?		✓			✓ ?		
5. Erosion surcharge and/or insurance combined with regulatory measures to lower damages	✓	?		✓	✓		✓		
6. Flood-related regulatory changes in erosion zones	✓ ?				✓		✓		
7. Erosion insurance in bluff areas susceptible to erosion but not flooding	✓	✓					✗ ?		
8. Relocation assistance and/or land acquisition								✓	✓
9. Shoreline protection measures (nourishment, dune restoration, and structural measures)							✓	✓	✓ ✗

Note: A ✓ indicates that the option is likely to help meet the evaluation criterion. An ✗ indicates that the option may be at cross-purposes with the criterion. A ? indicates that the effect is likely to be minimal or uncertain.

Does the change lead to reduced damage to structures?

Damage to two classes of structures—-those that exist today and those that have yet to be built—must be considered. Only options 8 and 9, relocation and various types of shoreline protection, can effectively reduce damage to existing structures. Information, insurance programs, and regulation all can influence the design and location of structures that have not yet been built. Options 5 and 6 (regulation) and 9 (shoreline protection) clearly can be designed to help avert erosion-related damage. The extent to which the information and insurance—options 3, 4, 5, and 7—can avert future damage depends on how these mechanisms are designed. Option 7, expanding erosion insurance into bluff areas, would need to be pursued with caution, because poor design might actually lead to an increase in damage, though at the same time it would serve to reduce the hardship if and when damage did occur.

Does the change lead to other desirable outcomes, such as environmental benefits or enhanced opportunities for recreation?

Again, options 8 and 9, relocation of structures and shoreline protection, are those most likely to lead to environmental improvements. On the other hand, measures such as the hardening of beaches can lead to environmental degradation.

Is the change cost-effective?

Finally, whether a particular option is cost-effective depends on the implementation and on who is paying the bill. Providing information alone (i.e., erosion mapping) can be cost-effective, but only if it is widely available and used to reduce future risks. Insurance, if costs are completely covered by those who hold insurance, is cost-effective for taxpayers, but each policyholder must judge whether it is cost-effective personally.

ANALYSIS OF OPTIONS

Option 1: Maintain the Status Quo

Over the next 60 years, erosion may claim one of four houses within 500 feet of the shoreline. Within this area, the expected damage from erosion is about equal to the expected damage from flooding, yet it is dealt with in a far more cursory fashion.

Nineteen of 30 coastal states currently incorporate erosion risks into the approval process for new construction close to the shore. Thus Congress may choose to leave consideration of erosion hazards completely to the states. However, the availability of erosion information, its quality, and its usage are inconsistent form state to state.

Although the program encourages communities to include erosion risks in their permitting decisions, it does not help them acquire the needed information. Because FIRMs do not incorporate erosion risk along with the flood risk that is displayed, the maps may even be misleading to some users.

The current program appears to pay for most erosion-related damages in low-lying areas, although coverage is limited on bluffs. However, current insurance rates do not reflect the magnitude of the erosion risk faced by any individual policyholder. Thus, claims by homeowners in erosion prone areas will have to be subsidized by others. Lastly, the regulatory components of the program were developed primarily to avert damage from flooding. Although quite successful in this regard, they are ineffective with respect to erosion. Therefore, new structures built to NFIP standards are subject to higher risk of damage from erosion than from flooding.

Option 2: Erosion Mapping and Dissemination Alone

Chapter 5 displayed examples of maps showing the expected location of the shoreline years from now. Such maps contain highly useful information. If FEMA were to do nothing other than prepare them, update them as needed, and make them readily available to communities in print and over the Internet, the maps undoubtedly would be widely consulted. Potential home buyers and builders already use FIRMs that show the location of flooding risks. Similar maps displaying long-term erosion rates used side-by-side with FIRMs, or FIRMs with information about erosion hazards superimposed, would provide a much more accurate picture of the risks that coastal structures face. The implementation of a NFIP erosion hazard study and mapping program would involve revising an estimated 3,915 FIRM panels for 258 coastal counties along 12,500 miles of ocean and Great Lakes shoreline, and cost approximately $44.2 million (see Box 6.1). Assuming the map is useful for approximately 10 years, annual costs would be on the order of $4 to $5 million per year (yr), or $350/mi per year.

On average, across a strip of land several hundred feet wide bordering the Atlantic and Gulf coasts, expected losses from erosion are comparable to those from flooding. In some communities, the added risks from erosion far overshadow those expected from flood alone. Thus, it is possible to get a false sense of security from using the FIRM alone. FEMA would be wise to correct the misleading impression given by the partial information (i.e., flood risk only) included on FIRMs.

It is quite difficult to estimate the effect that such information might have on future development decisions, but the effect would not have to be very large to justify the costs. In Chapter 5, estimates of annual erosion losses were presented, first assuming no growth and then assuming that all the lots that are empty today are filled. The difference—the losses that could be avoided if no building takes place in areas most susceptible to erosion—is roughly $100 million/yr for the value of the structures alone. Again, the mapping investment needed to inform such decisions is $5 million/yr, or 4 percent of the losses potentially avoided if all property owners were to choose to build elsewhere. The percentage savings varies by region, however. Potentially avoided damage to structures alone along the Atlantic and Gulf coasts average roughly $35,000/mi per year and $10,000/mi per year, respectively. Depending on the region, if such maps discourage more than 2 to 7 percent of development on currently empty lots within the 60-year erosion hazard area, the investment will be worthwhile.

Moreover, it is hard to envision another erosion-related expenditure that is likely to be more cost-effective for reducing damage. For example, later in this chapter, beach nourishment is estimated to cost between $300,000 and $500,000 per year per mile of shoreline. Thus an additional 10 miles of eroding coast could be nourished for the same annual cost of mapping the 12,500 miles of U.S. ocean and Great Lakes shoreline of greatest concern.

The funds required to map erosion might instead be used to improve estimates of flood risk. While this would be a worthwhile expenditure, far less information is available about erosion—a risk about equal to flood in the highest risk flood zones. Thus, adding erosion risks to current flood maps is likely to be the more cost-effective and useful choice.

BOX 6.1 Costs of Erosion Mapping

The implementation of an erosion hazard study and mapping program would involve revising an estimated 3,915 Flood Insurance Rate Map (FIRM) panels for 258 coastal counties along 12,500 ocean and Great Lakes shoreline miles, and cost approximately $44 million (see Table below). The Federal Emergency Management Agency (FEMA) would need to identify historical shorelines using geographic information system technology and then use these data to estimate erosion rates. Then, FEMA would need to prepare a report documenting the data development process and resulting erosion rates and plot the rates on existing FIRMs. Plotting the erosion rates on separate maps would save approximately $2.6 million. Other costs include appeals, administration, printing, and distribution. However, FEMA's Map Service Center would prefer to plot the erosion rate on existing FIRMS for two reasons: The present inventory management system cannot handle two separate products using an identical numbering scheme, and existing storage space could not handle an additional 4,080 panels.

Projected Costs of an Erosion Hazards Study and Mapping Program

Activity	Cost (1999 dollars)
Identification of historical shorelines	$18.8 million
Erosion data analysis	$13.4 million
Report and documentation (including plotting erosion rate on existing FIRMs)[a]	$8.5 million
Other (appeals processing, administrative costs, printing, and distribution	$3.5 million
Total	$44.2 million
Average cost per mile of mapped shoreline	$3,500

[a] Plotting erosion rates on new and separate maps would cost $5.9 million, or $2.6 million less, lowering total costs to $41.6 million.

SOURCE: Hatheway, 1999.

What sorts of changes to the current NFIP would such an option require? First, FEMA already has a technical support division that currently prepares and distributes FIRMs. Erosion mapping would likely be an added responsibility of that division. Following a procedure similar to the one used to prepare erosion maps for the 27 coastal counties in this study, the division could collect historic data from maps and photos and prepare a series of nationwide erosion maps. The maps could be distributed by the Map Service Center that already distributes FIRMs to individuals, local governments, insurance companies, and any others who are interested.

However, unlike flood maps, which exist primarily in printed form, erosion maps could be designed right from the start for both electronic and print formats. The availability of these maps on the Internet, in an easily accessible form, could lead to increased use of this information. The potential benefits of electronic access to flood information already has been recognized by FEMA, which follows this procedure for all FIRM remappings.

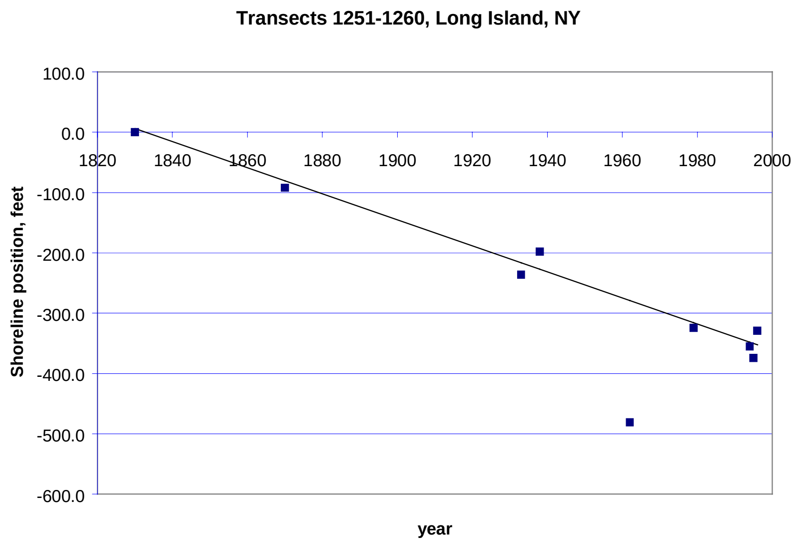
The erosion maps would need to be used with caution, however. Although these maps display well-defined lines, they reflect only a statistical "best guess" of how much the shore might erode over the next several decades, based on the long-term average erosion observed over the past several decades or century. Such projections are extremely useful but are only as accurate as the averaged historical data on which they are based. Erosion maps must also be updated periodically.

The data from which these maps are derived come from maps and aerial photographs showing the past location of the shore, such as the high water line or bluff line. The availability of such maps and photos is spotty; typically, an area is mapped or photographed only once every several decades. Moreover, the photos from the 1930s and 1940s can be difficult to interpret.

More significantly, erosion is a highly variable process. Figure 6.2 displays a typical graph of shoreline movement through time on Long Island, New York. Again, there are usually only a few observations of shoreline location from which to estimate future erosion rates. This region of Long Island, mapped nine times since 1830, has one of the longest records and is among the most frequently mapped. Although the shore appears to be eroding gradually at a fairly constant rate, large storms can cause large, rapid inland movements of the shore, which then may accrete over the period of a few years to the long-term average trend line. In this example, the long-term erosion rate has been about 2 ft/yr. Large storms hit in 1933 and 1962. In 1933, the coast appears to have eroded about 20 ft and then returned to the long-term average trend. In 1962, the short-term excursion was closer to 200 ft before the coast returned to the long-term trend.

Thus, in the near term, these maps are best viewed as displaying "risk zones" rather than future shoreline locations. Houses located in the 10-year zone are more likely to be found oceanside over the next several decades than are those located in the back of the 60-year zone. After 10 years, the shoreline may be close to where it is today or farther inland than the 10-year line. If the shoreline is recovering from a recent storm, then it may even be farther out towards the ocean. Over a long-term period of 60 years, the shoreline is expected to move at a distance approximately equal to the time period multiplied by the average annual erosion rate (e.g., 60 years multiplied by 2 ft/yr equals 120 ft). The 60-year line represents only the best guess of how far the shoreline will move. It is also important to remember that these long-term projections do not incorporate any future interventions, such as beach nourishment or hard structures.

FIGURE 6.2 The shoreline has moved quite a bit since 1830 on Long Island, New York, as shown in this graph. The solid line shows the long-term average trend in shoreline position. Large storms, such as the 1962 Ash Wednesday storm, can cause rapid, substantial inland movements of the shore, which then may accrete back to the long-term average trend line.



SOURCE: FIU Laboratory for Coastal Research, 1998

Option 3: Creation of a Coastal High Hazard Area, Including Both Flood and Erosion Zones

Among the simplest changes that Congress could make to incorporate erosion hazards more fully into the current flood program would be to direct FEMA to establish a single "coastal high hazard zone" encompassing the current highest-risk flood zone (the “V-zone”) and any additional areas highly susceptible to erosion. Insurance rates would increase to reflect both risks. On the Atlantic and Gulf coasts, the combined region would be roughly 15 percent larger than the current high-hazard V-zone.

Within the new coastal high hazard zone, 25 percent of the structures would be within both the current V-zone and the 60-year EHA, 65 percent in the current V-zone only, and 10 percent in the 60-year EHA only.

The Heinz Center estimates that the average expected damage in the new coastal high hazard area would be slightly greater than in the current V-zone, approximately $1.42/yr per $100 of coverage compared to the current V-zone average of $1.36/yr per $100 of coverage.

Rates could not be based entirely on flood risk, however, as they are under the current program. In addition to the current rates (based primarily on building characteristics in relation to expected flood heights), all policy holders would share equally the costs of erosion damage, about $0.70/yr per $100 of coverage. After adjusting for FIA administrative costs and the like, policyholders would see rate increases of about $0.92/yr per $100 of coverage. This is in addition to current rates that vary by flood risk. Incentives to elevate structures and use similar building methods to minimize flood damage would be retained. However, risks related primarily to house location, such as erosion risks, would be shared equally by all within the new coastal high hazard area.

This option contains the cost of erosion to within the coastal high hazard area, thus eliminating future subsidies from other NFIP policy holders (such as inland homeowners) and general taxpayers. The NFIPs current distribution of insurance is shown it Table 6.1. About 2 percent of policies and coverage are located in the coastal high hazard areas, thus the size of this new risk category would not be overly large.

The option does not, however, bring insurance rates fully into line with the risk faced by individual homeowners within the high hazard area. Policyholders in low-erosion areas still would be subsidizing those in more erosion-prone ones.

TABLE 6.1 NFIP Policies In Force and Coverage: All Zones and V-Zone Only

	Policies in Force	Premium (millions $)	Total Coverage (millions $)	Coverage per policy ($)	Cost ($/$100)	Average Premium ($)
All zones						
pre-FIRM	2,407,000	$950	$263,000	$109,000	$0.36	$394
post-FIRM	1,757,000	$530	$250,000	$142,000	$0.21	$303
Total all zones	4,164,000	$1,480	$513,000	$123,000	$0.29	$355
V-zone						
pre-FIRM, pre-81	48,000	$34.7	$5,190	$109,000	$0.67	$730
post-FIRM, pre-81	10,000	$6.1	$1,190	$118,000	$0.51	$602
post-FIRM, post-81	27,000	$26.3	$3,870	$144,000	$0.68	$981
post-FIRM total	37,000	$32.3	$5,060	$137,000	$0.64	$877
Total pre and post-FIRM V-zone	84,000	$67	$10,250	$121,000	$0.65	$794
V-zone as % of total	2%	5%	2%			

Data may not add to totals because of rounding.

Source: Federal Insurance Administration. October, 1999.

Option 4: Mandatory Erosion Surcharge on Existing Flood Insurance Policies

Congress may wish to distinguish coastal hazards, as addressed under the NFIP, into separate erosion risk and flood risk components. If these risks were treated separately, then policyholders with similar houses in erosion-prone areas would pay higher premiums than would those along non-eroding shores facing comparable risks of flooding. The most effective approach would be to instruct FEMA to construct a mandatory erosion surcharge applicable to all policy holders in designated erosion-prone areas. The surcharge *must* be mandatory because the flood program *already* pays for most of the losses from erosion sustained by current policyholders. If coverage were optional, there would be no incentive for policyholders to pay extra for coverage they get free of charge today. Moreover, it is not possible to distinguish adequately between damage from flooding alone and that from erosion-related flooding, such that the Federal Insurance Administration (FIA) could set different rates for homeowners wishing coverage with or without erosion damage.

A flood insurance policy could remain optional, as it is today, for those who do not hold federally backed mortgages. But, again, if the objective is to improve the fairness of the current program by adding an erosion surcharge, then it must be mandatory if flood insurance is purchased. Fairness is probably the most compelling reason in favor of a mandatory erosion surcharge. Homeowners in erosion hazard areas are paying the same amount for their flood insurance as are those in non-eroding areas, but the risks they face are greater. Thus, either homeowners in the non-eroding areas will be subsidizing future erosion damages in EHAs (hence paying more than they should) or the National Flood Insurance Fund (NFIF, established under the NFIP) will not be self-supporting and taxpayers will be subsidizing the fund. An erosion surcharge would help to remedy either situation.

On the other hand, some argue that a surcharge would further complicate what is already a rather complex flood insurance program that has separate rates for V-zones, lower risk A-zones, and so on. Most of the 60-year erosion hazard is confined to the V-zone. Moreover, the variation in flood risk within the V-zone nationwide is not completely accounted for in today's insurance rates. Ignoring the variation in erosion risk is but another simplification to keep the insurance program simple enough to implement.

Although there is clearly merit to this argument, the magnitude of the simplification is quite large. In Chapter 5, results were presented indicating that, on average, in these V-zones the magnitude of the risk from erosion was only slightly less than that posed by flooding alone. For new structures, the risk from erosion, on average, is 1.5 times the risk posed by flooding. Under the current program, a policyholder whose house is built at the height of the expected 100-

year flood crest will pay about twice as much for insurance as a neighbor whose house is built 2 ft higher. Thus, it seems inconsistent to pay close attention to the variation in flood risk when setting insurance rates and completely ignore the variation in erosion risk that is at least as great.

One argument voiced against an erosion surcharge is that such a policy might *increase* development in erosion-prone areas, as the current NFIP has done in V-zones. The Heinz Center research supports the conclusion that flood insurance has encouraged development in V-zones, but, because erosion damage already is covered under the program, an erosion surcharge actually might *lower* development in erosion-prone areas.

As discussed in Chapter 5, The Heinz Center-funded research team at George Washington University observed that development density was 25 percent lower in high flood hazard V-zones than in areas less susceptible to flood damage. However, after the adoption of the NFIP, the gap narrowed. During the early "emergency phase," density in V-zones averaged about 15 percent below that in areas with lower flood risk; after the regular program began, development density in V-zones was about 10 percent lower than in areas with lower flood risk.[13] The regular program instituted a series of changes: Flood Insurance Rate Maps (FIRMs) were published, insurance limits were raised, and building codes were issued. There is no way to estimate which of these factors was most responsible for narrowing the gap. Although these observed differences are significant, the effect of the NFIP is modest in comparison to some other factors, such as the rapid growth rates that prevail in coastal areas in general.

Again, at first glance, one might conclude that an erosion surcharge would spur development. However, The Heinz Center does not support this interpretation for the Atlantic and Gulf coasts. Flood-related erosion damage already is reimbursed under the NFIP; thus, the question is not whether to *pay* for such coverage, only whether to *charge separately* for it. Although insuring damage may have led to increased development density in the past, charging for the coverage, when it is now offered free of charge, can be expected to lower rates of development.

If Congress does choose to direct FEMA to establish an erosion surcharge, then Congressional guidance regarding several additional policy questions would be useful to the FIA administrator. These questions are listed in Box 6.2 and discussed below.

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[13] As discussed in Chapter 5, although development density increased, overall damage as a result of the program is expected to be lower than it would have been because houses are better built as a result of the program's new building codes.

BOX 6.2 Questions to be Addressed in Designing an Erosion Surcharge

1. Should the "flood component" of insurance rates for current policyholders be altered?
2. How many risk zones should there be?
3. Should all structures within a minimum number of feet of the shore, regardless of the erosion rate of that shoreline, be included in the erosion risk zone?
4. Should the existing subsidy policies of the flood program also apply to the erosion surcharge?
5. Will coverage include losses from "sunny day erosion"?

Should the "Flood Component" of Insurance Rates for Current Policyholders be Altered?

First, Congress could provide guidance to FEMA regarding how the existing flood insurance rate structure should be affected by the new surcharge program. If the policyholders in areas with high erosion are required to pay a surcharge, then should those in low or non-eroding areas be given reduced insurance rates? The Heinz Center analyses indicate that, unless Congress chooses to subsidize the current flood insurance policyholders for a risk that is currently being underestimated, it should avoid doing so.

The existing rate structure for new construction in the high hazard flood zone (V-zone) was devised by FEMA in the early 1980s by melding a simplified engineering damage model with observations of damage that occurred during a few major storms (Federal Emergency Management Agency, 1981). Insurance rates are determined primarily by the elevation of a structure compared to the expected wave crest height during a 100-year storm, and by a few other characteristics of the structure itself. Erosion-related damage was incorporated indirectly into FEMA's estimate of expected damage insofar as it was a factor in the storms analyzed, but the effects of long-term erosion are not included in a systematic fashion. In Chapter 5, it was estimated that, within the V-zones of the Atlantic and Gulf Coasts, expected erosion damages alone are only slightly less than the amount estimated by FEMA's current damage model for flood and erosion combined. Therefore, The Heinz Center concluded that, although some erosion damage might be incorporated into FEMA's current damage model, the erosion component is too low.

Nevertheless, Congress could direct FEMA to lower the flood component of the new insurance rate structure that separately evaluates flood and erosion risks. Of course, doing so would hold down rate increases to policyholders in eroding areas and reduce rates for policyholders in non-eroding area who may have been paying too much. But unless this reduction in insurance rate is quite modest, Heinz Center analyses indicate that the damage claims, over the long term, likely will exceed the premiums collected.

How Many Risk Zones Should There Be?

Next, Congress must guide FEMA on how fine-grained the erosion surcharge should be—that is, how many "risk classes" should be established. This is both a policy judgment and a technical one. For example, Congress could set a single surcharge for the entire erosion zone. The Heinz Center used an erosion zone of 60 years as the largest zone, although this certainly could be somewhat larger or smaller. Sixty years is almost the life of a typical house and a zone size already in use by several states.

The key point is not the size of the zone, but rather that a single surcharge would apply to all flood insurance policies inside the zone. Those closest to the shore would be paying less than their expected share of the risk, and those farthest landward would be paying more.

A finer-grained program could establish several zones, as recommended in an earlier report by the National Research Council (1990). As an example, The Heinz Center constructed a surcharge based on three zones: 0 to 10 years from the erosion reference feature, 10 to 30 years, and 30 to 60 years from the erosion reference feature. For new structures, surcharges were estimated for all three zones such that the premiums charged within each zone would cover the cost of insurance payouts for damage. For existing structures, separate surcharges were developed based on two zones: 0 to 30 years from the erosion reference feature, and 30 to 60 years. The rationale for the less fine-grained rating scheme for existing structures is that once a house is built, a homeowner has no way to avoid the highest rates that would apply in the 0 to 10 year zone, except to decline insurance. Someone planning a structure in the highest risk areas can choose to build elsewhere.

However, such a program might be quite difficult to implement and apply in the field. For an area eroding 2 ft/yr, the 0- to 10-yr erosion hazard area would be 20 feet wide. This would be barely discernable on a map of the scale typically used by FEMA, thus difficult for an agent to correctly identify the appropriate classification of a structure. Therefore, The Heinz Center also constructed an option with a single, 0- to 60-year EHA for existing structures and two zones, 0- to 20-year EHA and 20- to 40-year EHA, for new structures.

Approximate rate increases for a series of surcharge options are presented in the following five tables. Table 6.2 provides surcharges for the simplest, the single-zone option in which the same surcharge applies to all structures, existing and new, throughout the entire 60-year erosion zone. Table 6.3 displays the surcharges for a program based on a single zone for existing structures and two zones for new structures. Tables 6.4 and 6.5 display surcharges for options that include two zones for existing structures and three for new ones. Table 6.4 provides rates for a fixed fee over the life of the structure. Table 6.5 shows a sliding scale with surcharges rising as a house advances to zones closer to the erosion reference feature. Finally, Table 6.6 shows an option where surcharges apply only after a structure enters the 0 to 30 year zone.

The surcharges assume that FEMA remaps the erosion zones every 10 years and after every large erosion event. The tables display the surcharges that apply when the program begins, and the new surcharges that would apply if a structure is found to be closer to the shoreline in a subsequent remapping. Again, these are surcharges that are added to flood insurance rates.

Option 4 (Table 6.5) charges lower rates to start for structures that are estimated to be 30 to 60 years away from the eroding shore. However, if the fund is to remain revenue neutral, then the surcharge must be raised after erosion results in a structure being located closer to the shore. Such a sliding scale may seem to be the fairest approach, but it is more complicated to administer and more likely to result in revenue losses if a major storm hits in the early years of the program.

Another factor in this choice of surcharge options is the effect that the new insurance price might have on program enrollment. Flood insurance is required for holders of federally backed mortgages, but over half of the houses in The Heinz Center sample do not fall in this category. Flood insurance is optional for those able to finance without federally backed loans. In the mail survey by the research group at the University of Georgia, homeowners were asked how much they would be willing to pay for optional erosion insurance. The analyzed results are shown in Figure 6.3.

About half of the policyholders stated that they would be willing to pay for optional erosion insurance if it cost less than $1–$2/yr per $100 of coverage. However, at rates of $5/yr per $100 of coverage, voluntary participation would be quite low. Accordingly, one might anticipate that, under a program establishing a single, uniform surcharge across the 60-year EHA, most of the homeowners that voluntarily buy flood insurance today would maintain coverage with the surcharge added. However, with surcharges of the magnitude of those shown for the multi-zone options, many of these same homeowners might drop their insurance.

Within The Heinz Center study areas, roughly 41 percent of the property owners purchased flood insurance. Approximately 32 percent were required to have it to obtain federally backed loans, and the remaining 9 percent of owners purchased it voluntarily.

TABLE 6.2 Surcharge Option 1, Surcharges[a] Fixed for Life of Structure, Single 60-year Zone

Location Where Structure is Built[b]	New Structures	Existing, Post-1981 Structures	Subsidized Structures
0- to 60-year EHA[c]	$2.75	$2.45	$0.75
Outside 60-year EHA			
When in 0- to 60-year zone	$0.95	$0.95	$0.35
When outside 60-year zone	$0.00	$0.00	$0.00

[a] Surcharges are given in dollars per year per $100 of coverage for a 1-4 family residence. Rates for new structures and post-1981 structures are calculated to be revenue neutral within each zone. Assumptions: Federal Insurance Administration (FIA) pays for 85 percent of damage (remainder is wind damage paid for by private insurers); interest rate is 3 percent; FIA overhead is 35 percent; subsidized structures pay 38 percent of post-81 rates. Surcharges for existing structures are based on observed distribution of structures within a zone; surcharges for new structures assume a random distribution of structures within zones.
[b] New structures assumed to be randomly distributed; location of existing structures based on observed distribution within Atlantic Coast counties.
[c] Erosion hazard area.

TABLE 6.3 Surcharge Option 2, Surcharge [a] Fixed for Life of Structure, Single Zone for Existing Structures, Two Zones for New Structures

Location Where Structure is Built[b]	New Structures	Existing, Post-1981 Structures	Subsidized Structures
0- to 20-year EHA[c]	$11.40	$2.45	$.75
20- to 60-year EHA	$1.75	$2.45	$.75
Outside 60-year EHA			
When in 0- to 60-year zone	$0.95	$0.95	$0.35
When outside 60-year zone	$0.00	$0.00	$0.00

[a,b,c] See footnotes in Table 6.2

TABLE 6.4 Surcharge Option 3, Surcharge [a] Fixed for Life of Structure, Two Zones for Existing Structures, Three Zones for New Structures

Location Where Structure is Built[b]	New Structures	Existing, Post-1981 Structures	Subsidized Structures
0- to 10-year EHA[c]	$24.60	$7.60	$2.90
10- to 30-year EHA	$4.90	$7.60	$2.90
30- to 60-year EHA	$1.40	$1.30	$0.50
Outside 60-year EHA			
When in 0- to 60-year zone	$0.95	$0.95	$0.35
When outside 60-year zone	$0.00	$0.00	$0.00

[a,b,c] See footnotes in Table 6.2

TABLE 6.5: Surcharge Option 4, Surcharge [a] Varies Over Life of Structure for Those Starting in 30- to 60-year Erosion Hazard Area

Location Where Structure is Built[b]	New Structures	Existing, Post-1981 Structures	Subsidized, Pre-1981
0- to 10-year EHA[c]	$24.60	$7.60	$2.90
10- to 30-year EHA	$4.90	$7.60	$2.15
30- to 60-year EHA			
When in 0- to 30-year zone	$2.05	$1.85	$0.70
When in 30- to 60-year zone	$1.00	$1.00	$0.40
Outside 60-year EHA			
When in 0- to 30-year zone	$1.50	$1.50	$0.60
When in 30- to 60-year zone	$0.75	$0.75	$0.30
When outside 60-year zone	$0.00	$0.00	$0.00

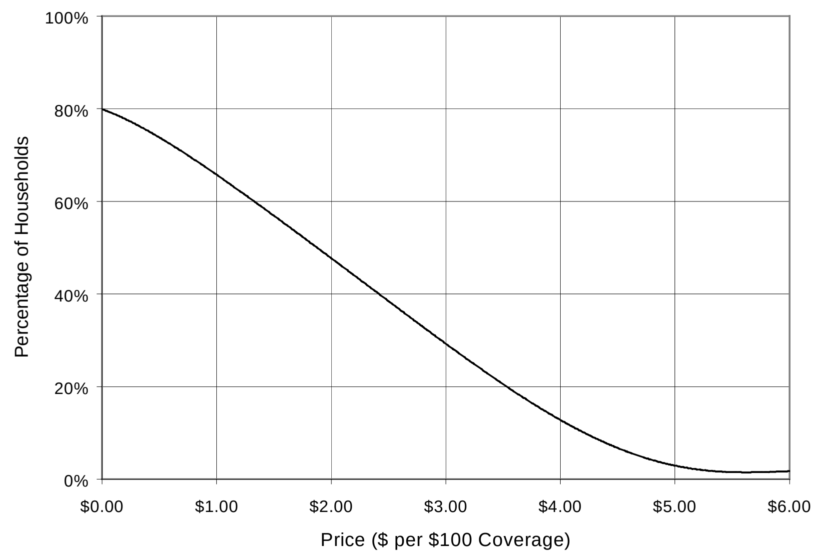
[a,b,c] See footnotes in Table 6.2

TABLE 6.6 Surcharge Option 5, Surcharge [a] Required Only for Structures Inside 30-year Erosion Hazard Area

Location Where Structure is Built[b]	New Structures	Existing, Post-1981 Structures	Subsidized, Pre-1981
0- to 10-year EHA[c]	$24.60	$7.60	$2.90
10- to 30-year EHA	$4.90	$7.60	$2.90
Outside 30 year EHA			
When in 0- to 30-year zone	$3.60	$3.60	$1.35
When outside 30-year zone	$0.00	$0.00	$0.00

[a,b,c] See footnotes in Table 6.2

FIGURE 6.3 The percentage of homeowners willing to voluntarily purchase erosion policies declines as the cost rises.



Should All Structures Within a Minimum Number of Feet of the Shore, Regardless of the Erosion Rate of that Shoreline, Be Included in the Erosion Risk Zone?

All of the surcharge alternatives presented in the preceding section are based on expected long-term erosion rates alone, estimated from the movement of the shoreline over many decades. Although the shore may appear to be consistently eroding, in many areas it is not. Sometimes large storms can cause very large movements of the shore inland, far past what is expected based on the long-term trend. Over a period of a few years to a decade, the beach accretes partway, but not all the way, back to its old location (as illustrated earlier, in Figure 6.1). Although the beach may return by itself, a house that was lost to erosion obviously will not. Thus, even in areas with low long-term erosion rates, houses close to the shore face some risk of damage because of erosion.

Figure 6.4 displays data for 14 large storm-related erosion events recorded along eight sections of the Atlantic Coast since about 1850. The variability is high, but the average distance eroded is about 140 ft inland—the distance one might expect after 70 years given a rather typical long-term erosion rate of 2 ft/yr. Figure 6.5 plots the erosion distances of these very large events against the long-term erosion rate of the relevant section of the coast to determine if there is any relationship. In these eight sections of the coast—chosen only for the length of record available and frequency of remapping—no relationship is apparent. A house 50 or 100 ft inland, no matter how low its long-term erosion rate, appears to be susceptible to large erosion events.

FIGURE 6.4 The extent of shore erosion varied widely among 14 major storm events on eight sections of the Atlantic Coast, 1850–present.

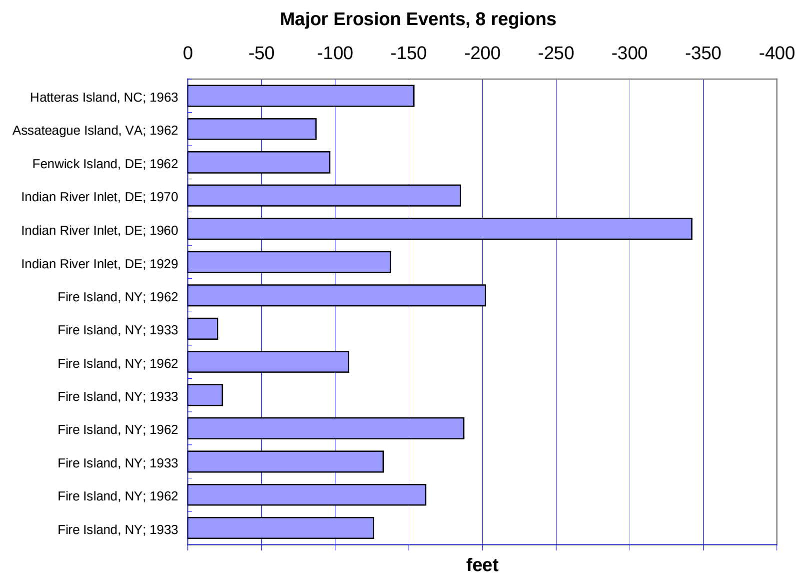
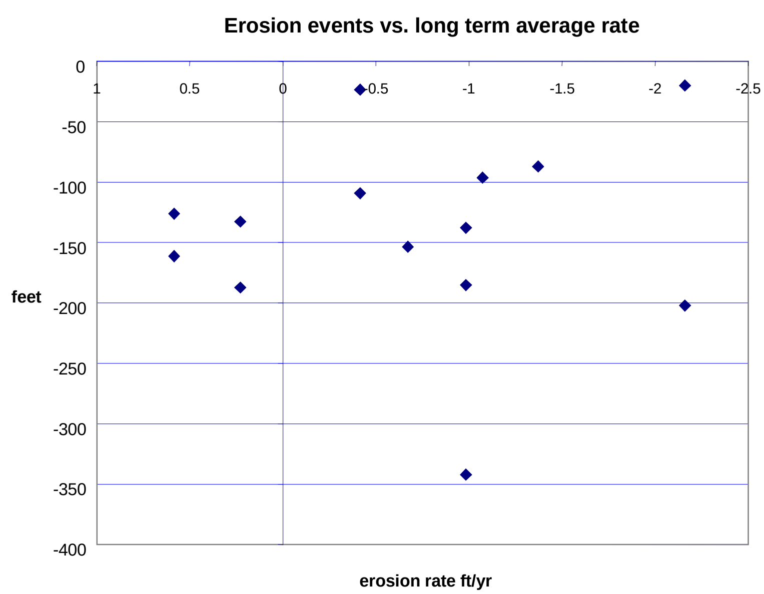
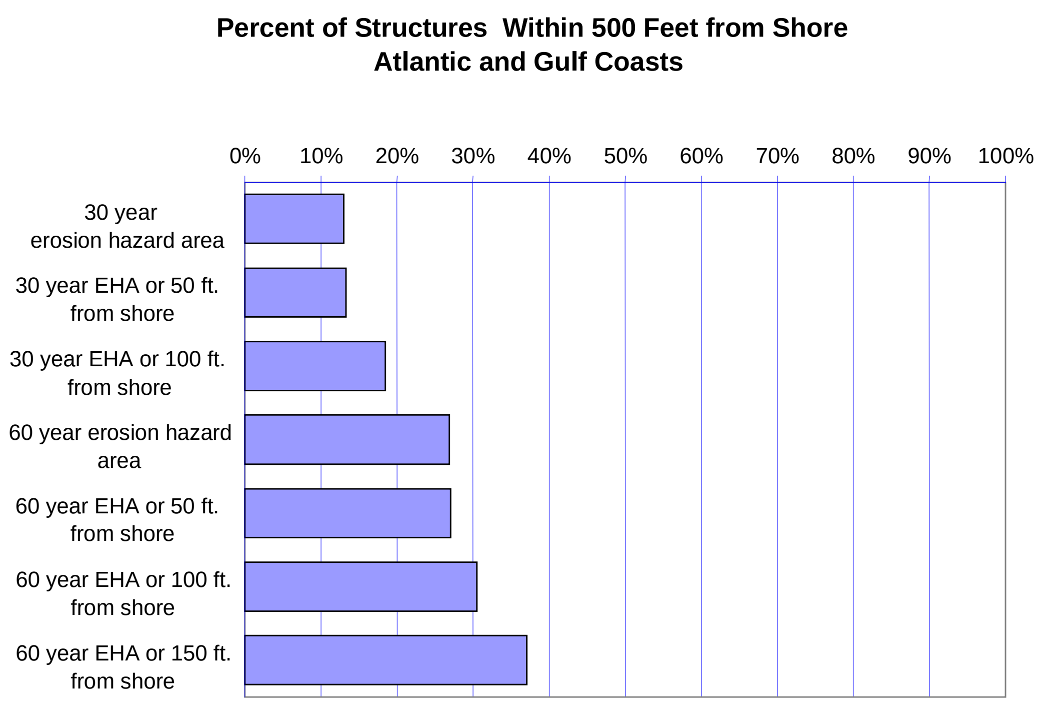


FIGURE 6.5 The extent of shore erosion during major storms is unrelated to long-term erosion rates, as illustrated by this plot for 14 major storm events on eight sections of the Atlantic Coast, 1850-present.



Thus, in principle, it seems appropriate to use distance in feet from the shoreline as a criterion for defining the EHA, in addition to the 10-year, 30-year, and 60-year zones discussed previously. Unfortunately, it was not possible to gather sufficient data to quantify this risk and estimate insurance rates similar to those presented in the preceding section. It is possible to state that, in the eight areas depicted in Figure 6.4 and Figure 6.5, major storm events occur, on average, once or twice every century, and, at this frequency, erosion distances of 100 to 150 ft inland are not unusual. Figure 6.6 presents estimates of the structures that would be added to the 30-year and 60-year EHAs along the Atlantic and Gulf coasts if a "distance buffer" were included to account for these large, infrequent erosion events. For example, 27 percent of structures within 500 ft of the Atlantic and Gulf shorelines are located within the 60-year EHA. Adding a buffer zone that includes all houses within 100 ft of the shore expands the EHA to include 31 percent of structures within 500 ft of the shore.

FIGURE 6.6 The use of a distance buffer as a criterion for inclusion in an erosion hazard area generally would increase the number of structures affected.



Should the Existing Subsidy Policies of the Flood Program Apply to the Erosion Surcharge?

A fourth decision that Congress must make is whether to subsidize the erosion surcharge for policyholders who either do or can obtain subsidized flood insurance today—or even subsidize the erosion surcharge for all existing structures.

Roughly 70 percent of the structures in V-zones were built prior to 1981 and thus eligible for some subsidy. Over half were built prior to the issuance of a FIRM and are eligible for insurance rates that are between 35 and 40 percent of the rates they would pay if the structure had been built after the issuance of a FIRM (See Table 6.1). However, not all eligible policyholders choose to follow the rules that apply to subsidized structures. A policyholder with an older house that was built high enough may pay less for insurance under the full-risk rates than by following the procedures used to set subsidized rates.

As mentioned earlier, erosion coverage has been a de facto part of the current program, thus many policyholders now have subsidized erosion coverage. Congress could take this opportunity to eliminate at least part of the subsidy, or, if there is a desire to maintain it, direct FEMA to reduce the surcharge for these policyholders by a percentage equivalent to that they already receive. Congress must also decide whether to extend subsidies to those who are eligible for it today, but who have declined to accept it.

Congress could also instruct FEMA to offer subsidized rates to *all* current policyholders. This was the approach followed during the last major revision of V-zone policy in 1981. At that time, FEMA revised its procedure for estimating expected flood heights upward. Many structures that were built to what were thought to be safe levels are now understood to be at greater risk. FEMA followed the principle that structures that were built prior to full knowledge of the risk should not be charged full-risk rates. Today, however, roughly 70 percent of available lots in the 60-yr EHA already have houses. Thus, if Congress chooses to follow this principle for erosion, few structures would ever be charged rates sufficient to cover the risks that they face.

Will Coverage Include Losses from "Sunny Day Erosion"?

Finally, Congress must decide whether to expand the coverage of the current flood program. Under the current program, erosion-related damage to structures that occurs during times when there is no flooding (i.e., so-called "sunny day erosion") is *not* covered. Except for situations in which houses are situated on bluffs (e.g., along the Great Lakes and parts of the West Coast), most erosion-related damage appears to occur during storm events.

The FIA's claims records include very few instances of claims being denied because they were caused by sunny day erosion. There was some concern that this apparent lack of evidence might be misleading, because insurance agents might be discouraging their clients from pursuing such claims at all. One member of The Heinz Center research team, a former insurance industry actuary, conducted a telephone survey of 16 insurance agents active within the study counties to determine the extent to which claims of sunny day erosion have been discouraged. None of the agents knew firsthand of damage from sunny day erosion or of claims being discouraged. Thus, if Congress chooses to incorporate erosion damage explicitly into the rate structure, then it also might choose to expand coverage to include damages that occur during times when there is no flooding, with an expectation of only modest increases in the number of claims.

Option 5: Erosion Surcharge Combined with Regulatory and Similar Measures to Lower Damages

As discussed in Chapter 3, the current NFIP includes both "carrots" (insurance) and "sticks" (regulatory requirements). The Congress established a program that offers homeowners within a participating community the benefits of federally backed flood insurance only if the community is willing to undertake regulatory measures that will help to lower future damages. Chief among these measures are building standards that require that houses be elevated so that the first floor is higher than the flood crest expected from a 100-year storm.

Congress might choose to apply the same philosophy to an expanded insurance program that includes an erosion surcharge, such as the ones discussed in the previous section. Box 6.3 presents a series of regulatory and other restrictive options that could be required along with an erosion surcharge. Like the measures in the current program, most of these would apply to structures built after the date on which new regulations are issued.

Several of these measures would be implemented by the local communities and states, which already are responsible for the bulk of the NFIP regulatory requirements. Regulatory requirements for setbacks already have been implemented in roughly three-quarters of coastal states and territories. Setback requirements limit building within a specified distance from the shoreline, for example, 75 ft from the shoreline in Maryland or outside the expected 30-year erosion zone in New Jersey. Table 6.7 and Table 6.8 summarize, using different criteria, the highly varied regulations currently in place (see Chapter 4 for more information.) Congress could direct FEMA to establish a minimum requirement that communities must adopt to remain eligible for the new combined flood and erosion insurance. States would be free to specify more restrictive requirements.

A setback specified in years from the shoreline would be most consistent with the insurance surcharge discussed in the previous option. Table 6.9 displays estimates of the impact of setback requirements on property owners along the Atlantic and Gulf coasts. For this analysis, it was assumed that owners of empty lots that do not have at least 50 ft behind the stated setback distance will lose the option to build a house. The Table displays the percentage of currently empty lots within 500 ft of the shoreline that would not have adequate room for a house if a setback requirement were adopted. Note, however, that many of these lots are already affected by state requirements (see Tables 6.7 and 6.8), in particular those on the Atlantic and those closest to the shoreline.

A 60-year setback requirement would constrain development on approximately one-third of the empty lots within 500 ft of the shore. A 30-year setback would prevent development on roughly 20 percent of currently empty lots within 500 ft of the Atlantic coast and about 10 percent on the Gulf. Finally, a 10-year setback would prevent development on approximately 15 percent of currently empty lots within 500 ft of the Atlantic coast and fewer than 5 percent on the Gulf.

The adoption of an additional setback requirement measured in feet would add a margin of safety for those areas in which long-term erosion rates may be low (or those with accreting shorelines), but that are still susceptible to storm-induced erosion events. Minimum requirements for both criteria (e.g., 10 years or 50 ft, whichever is greater) would be the most robust option. North Carolina follows this approach, requiring a setback landward of the 30-year erosion line and at least 60 ft from the first line of stable vegetation.

BOX 6.3 Possible Regulatory Guidelines and Other Restrictive Measures to Lower Damages

Regulatory measures that the local community must adopt to qualify for insurance:

- mandatory setback provisions for new construction;
- building code changes to allow for easy relocation of structures, and requirements for removal if a structure gets too close to the shoreline; and
- other building code changes.

Measures that must be mandated by the Federal Emergency Management Agency:

- denial of insurance for new structures in highest-risk erosion zones; and
- revocation of insurance for structures that end up in highest-risk erosion zones.

TABLE 6.7 State Coastal Setback Provisions Using Erosion Rate or Combination of Measures[a]

FL	30-year erosion line for major structures from SHWL
MI	Bluff high risk area setback 30-year erosion projection plus 15 feet (ft)
NC	Structures less than 5,000 ft^2, setback landward of 30-year erosion rate, crest of primary dune, toe of frontal dune, 60 ft from first line of stable vegetation. For lots platted before law: structures greater than 5,000 ft^2, 60-year erosion rate or 120 ft from mean vegetation line
NJ	V-zone setback for residential; 30-year erosion for 1–4 DU; 60-year erosion setback for larger structures in erosion hazard areas; baseline for setback varies by site (crest of coastal bluff, dune crest, first line of vegetation, landward edge of 8-ft elevation)
PA	Bluff setback of 50 times annual rate of recession from the bluff face for residential; 75 times for commercial, at least 50 ft
RI	50 ft from coastal features or 25 ft from coastal buffer zone; 30-yr erosion rate for 1–4 DU, 60-year erosion rate for larger structures in critical erosion areas; dune construction setback on 3 barrier beaches seaward of utilities/wall of existing development; no development on beach face, sand dune, undeveloped barrier beaches
VA	30-year erosion rate or 20 times local recession rate from MHW for barrier islands

[a] Two states (CA, WA) have local setbacks; six states (AK, CT, GA, LA, MA, MS) have no setbacks. No data available on MN.

TABLE 6.8 State Coastal Setback Provisions Using Distance and Various Other Measures [a]

AL	1040 feet (ft) landward of crest line (120–450 ft landward of MHWL)
AR	25 ft for residential; 50 ft for commercial
DE	100 ft landward of seaward-most 7-ft elevation above NGVD
HI	40 ft along most shorelines to upper reaches of wash of waves, usually evidenced by edge of vegetation growth, debris.
MD	75 ft from NHW
MI	Sand dune setback 100 ft landward from crest of first landward ridge not a foredune
ME	No structures on frontal dunes seaward of 100-year floodplain and sea level rise area; shoreline setback 75 ft for residential; 25 ft for general development/commercial; 250 ft from NHWL in resource protection areas
NH	100 ft from HOTL bordering tidal waters
NY	No moveable structures or major additions within environmental hazard areas
OR	No building within beach zone; no building on beaches, active foredunes, other conditionally stable foredunes subject to ocean undercutting and wave overtopping, and or intertidal plains subject to ocean flooding
SC	From MHW to crest of primary oceanfront sand dunes
TX	No construction is permitted seaward of the vegetation line. Structures erected seaward of the vegetation line (or other applicable easement boundary) or that become seaward of the vegetation line as a result of natural processes are subject to removal.
WI	75 ft from OMHW

[a] See Footnotes in Table 6.3(a).

Key:

APC	Area of Particular Concern	NGVD	National Geodetic Vertical Datum
DU	Dwelling Unit	NHWL	Normal High Water Line
HOTL	High Ordinary Tide Line	OHWL	Ordinary High Water Line
MHW	Mean High Water	OMHW	Ordinary Mean High Water
MHW(L)	Mean High Water (Level)	SF	Single Family housing units
MLT	Mean Low Tide	SHWL	Seasonal High Water Line

SOURCE: Bernd-Cohen and Gordon (1998).

TABLE 6.9 Unbuilt Parcels Affected by Setback Requirements

Type of Setback in Force	Empty Lots Within 500 ft of Atlantic Coast with No Room for House [a]	Empty Lots Within 500 ft of Gulf of Mexico With No Room for House
10-year setback	14%	3%
30-year setback	20%	12%
60-year setback	32%	29%

[a] Lots that do not have at least 50 feet outside the setback zone are considered unbuildable. Many of these lots are already affected by state requirements.

A key issue associated with this option for Congress is whether the public benefits of setback requirements outweigh the potential hardship from imposing restrictions on how individuals may use their land. Platt (1999), in an examination of natural hazards policy, addresses the other side of the question this way: "How much should communities and individuals be expected (read 'required') to do for themselves as a condition of federal assistance?" Homeowners located along an eroding shore receive two major types of federal assistance. First, the federal government began the NFIP because private insurers were unwilling to insure flood and erosion risks. By making insurance widely available, even with the changes proposed under the previous option to align rates more closely with the total risk to coastal houses, the government provides enormous help to many communities. Second, if a developed strip of shore is eroded by a major storm and a disaster is declared, public funds will likely be used to help the community recover. Typical activities include debris removal, road and beach access repair, increased costs of fire and police protection, berm and bulkhead repairs, and similar assistance to communities (rather than individuals). The federal government's share of these "public" costs is 75%; the communities receiving the aid pay the remaining 25%. In some circumstances, however, the federal government's share of disaster assistance costs can increase (Carl Frontin, Federal Emergency Management Agency, personal communication, March 10, 2000).[14]

Some but not all of future public assistance costs might be avoided if a setback were to be required. The Heinz Center attempted to estimate how such avoidable public disaster assistance costs compare to private damage claims for three major storms in two of its study sites: Hurricane Hugo in 1989 in Brunswick County, North Carolina; Hurricane Fran in 1996, again in Brunswick County; and a major nor'easter in 1992 in Sussex County, Delaware. This type of comparison can provide a rough indication of the magnitude of taxpayer subsidy potentially avoidable through setbacks.

[14] For example, in 1996 after Hurricane Fran, the Federal government paid 90% of total disaster assistance costs.

Summed over the three storms, Federal public assistance for flood- and erosion-related damage to the coastal communities of Brunswick and Sussex County totaled about $1.9 million (FEMA, 2000). Again, not all of these costs would have been avoided if a setback had been in effect. To get an idea of the impact of setbacks on reducing damage, public assistance funds were further broken down into two categories: those that would be affected by a setback (e.g., repair of sand fences and bulkheads) and those that would not (e.g., rebuilding of public beach accesses and facilities). Averaged over the three storms, approximately 15% to 35% of the $1.9 million paid by the Federal government for public assistance—$300,000 to $700,000—might have been avoided if all houses had been setback from the coast.

For comparison, the NFIP paid about $20 million in claims to V-zone homeowners during these storms. Thus, for the small sample of storms and counties examined, potentially avoidable Federal public assistance costs were roughly equal to 1 to 3 percent of the private claims paid by the FIA.

The results were highly variable from storm to storm, however, and thus must be used with some caution. For Hurricane Hugo in Brunswick County and the large nor'easter in Sussex County, the magnitude of potentially avoidable taxpayer assistance equaled roughly 1 to 2 percent of insured claims. For Hurricane Fran in Brunswick County, potentially avoidable disaster assistance costs were equal to roughly 50 to 80 percent of the flood insurance claims paid by FIA.

Assuming these results are representative, however, the magnitude of avoided public assistance does not appear to be a sufficient reason to justify Federally mandated setbacks. (The sample covers roughly 6 percent of total V-zone claims during the 13-year period between 1986 and 1998.) However, further examination of historic experience is needed.

Another option available to Congress is to direct FEMA to require communities to adopt building code changes to reduce the impacts of erosion-related damages. For example, structures could be designed so that they could be moved and relocated more easily in the event that an eroding shore gets too close. Removal of a structure that ends up within, for example, the 10-year erosion line also could be required.

Congress could follow a different path if there is hesitancy to assign additional regulatory burdens to states and localities. They might simply choose to deny insurance—for both flooding and erosion—to new structures in the highest-risk erosion zones. Building in these areas would not be prohibited, but the lack of availability of federal insurance would tend to discourage the rate of development. This is similar to the approach followed in the Coastal Barrier Resources Act, discussed in Chapter 3.

Congress might also choose to deny or revoke insurance for all structures that end up in the highest-risk zones, such as on the ocean side of the 10-year line. This would be an incentive for the owners of such structures to move them prior to damage. Congress could limit this option to structures built after a specified date, that is, to “grandfather” structures built prior to the regulation. Currently, FEMA can deny insurance to structures that are on the ocean side of the mean high water line, but it is unclear how often insurance is revoked once it has been issued.

Option 6: Flood-related Regulatory Changes in Erosion Zones

Current building codes under the NFIP are based on the assumption that the height and wave velocity from the expected 100-year flood will remain constant over the life of the structure. Chapter 5 presented results indicating this assumption is invalid for erosion-prone areas. Over time, erosion increases the risk from flooding.

To deal with this problem, Congress could instruct FEMA to require newly constructed houses, or houses rebuilt after substantial damage, that are located in flood zones also susceptible to erosion to meet building codes with an added margin of safety based on the anticipated erosion of the coast. For example, if Congress chose a 30-year margin of safety, then any new house expected to enter the V-zone within 30 years—even though it may be outside of the V-zone today—would be required to build to the more stringent V-zone standards. Throughout the Atlantic and Gulf coasts, the stricter building standards would apply to an area 15 percent larger than today’s V-zone.

Similarly, the height of a flood crest from a 100-year storm in an eroding area is likely to be higher in 30 years than it is today. Averaged across the Atlantic and Gulf coasts, flood heights are likely to be 8 inches higher in 30 years than they are today. The addition of a margin of safety would mean that new homes in such erosion-prone areas might be elevated an additional 0.5 ft to 1 ft.

It was not possible to ascertain how large a margin of safety would be cost-effective. Clearly, building in additional flood resistance is cheaper during the design and building phases than it is after a structure has been built. But the larger the margin of safety, the less likely that the additional investment will pay off in a reasonable amount of time. Congress could specify its intent for the margin of safety (e.g., cost-effective at current interest rates over 30 years) and direct FEMA to design the appropriate regulatory changes. Such changes might include elevating structures somewhat higher and even simpler modifications, such as stronger deck and joist supports.

Option 7: Offer Erosion Insurance in Bluff Areas Susceptible to Erosion but not Flooding

Approximately 20 percent of the homes within a 60-year EHA nationwide are located on bluffs. Most homes in low-lying erosion zones are also subject to flooding; roughly half of these have flood insurance. In contrast, 10 percent or fewer of the susceptible structures in the bluff areas of the Great Lakes and Pacific coasts are covered.

Coverage may be low in bluff areas because the National Flood Insurance Act, as amended in 1973, limits coverage of erosion damage to that "caused by waves or currents of waters exceeding anticipated cyclical levels." Hence, there at least appears to be a greater likelihood of a claim being rejected for bluff areas than for low-lying areas. For most houses on bluffs, flooding is not a problem, so the uncertain prospect of being reimbursed for erosion damage may be enough to discourage the purchase of insurance. Coverage might also be low because homeowners are not aware of, or are not willing to believe, the risks they face.

Although the magnitude of erosion losses is lower in the bluff areas of the Great Lakes and Pacific coasts than along the Atlantic and Gulf, expected annual damages are roughly $100 million per year. Congress may wish to help alleviate the hardship from erosion in bluff areas, too, and modify the NFIP rules so that insurance is more attractive.

If Congress does choose to expand insurance coverage in bluff areas, then it should carefully consider the potential for such coverage to encourage development in eroding areas. The NFIP appears to have contributed to increased development in flood-prone areas, but, because of the effectiveness of associated building codes, overall damage to structures has dropped. With erosion, however, there is no architectural solution; once the land is lost, no structure will survive.

Nevertheless, it is not clear whether offering insurance on bluffs would increase development as it did in low-lying areas. People may have been more willing to build in flood prone areas because they realized that the improved building practices, on balance, made the decision less risky than before. Moreover, houses insured under the early years of the NFIP were offered heavily subsidized rates. Such subsidies make the decision to build somewhat more attractive and in theory will lead to both greater density and damage.

Accordingly, if coverage is expanded to include existing structures on bluff areas, Congress might construct different rules for houses not yet built. Congress could just refrain from offering insurance to new houses built within erosion zones after they have been mapped and the results communicated widely. A fairer approach might be to offer insurance, making certain that rates are not subsidized. The ability to buy insurance might also be made conditional on adoption of building codes that allow structures to be easily moved in the event that the eroding bluff gets too close.

Option 8: Relocation Assistance and/or Land Acquisition

Along the Atlantic and Gulf coasts, approximately 20,000 structures are located within the 30-year erosion zone closest to the shore. The Heinz Center estimates that roughly 10,000 structures are within the estimated 10-year erosion zone closest to the shore, subject to an even more imminent hazard. For such high-risk structures, Congress might consider a program of relocation assistance and/or land acquisition to encourage removal of these structures *before* they are destroyed.

Relocation Assistance

Under current policy, if an insured building is damaged by a flood and the state or community declares the building to be substantially damaged, the NFIP will help pay to relocate the structure, up to a maximum benefit of $15,000 ($20,000 after May 1, 2000). This is in addition to coverage for repair of physical damage from flooding.

Between 1987 and 1994, the Upton-Jones Program of the NFIP offered policyholders in the highest-risk erosion zones the option of receiving 40 percent of the insured value of the structure for removal or up to 110 percent of the value of the structure if demolished. The program resulted in payments for about 600 structures, only one-quarter of which were relocated. The program was considered a failure and eliminated in 1994.

Such a program might make more sense if linked to some of the regulatory options discussed under Option 5 above. If, for example, Congress chooses to revoke insurance once a structure enters the 10-year erosion zone, or to require relocation as a condition for obtaining insurance, then relocation or demolition assistance can be viewed as compensation for the loss of use of the coastal property or the drop in value because of the loss of insurance. Although few policyholders made use of relocation assistance under the Upton-Jones Program, it seems reasonable to conclude that many more would be willing to do so if they were about to lose their flood insurance.

Land Acquisition

Currently, 21 coastal states have acquisition and relocation policies or programs specifically for hazard mitigation purposes in flood-prone or high erosion hazard areas. Thirteen of these 21 states have dedicated funds for direct state acquisition or local acquisition. In addition, many states help local governments obtain federal post-disaster funds. To date, land acquisition has been modest in oceanfront areas because of high land values.

However, as a result of damage from Hurricane Floyd in 1999, North Carolina will spend a few million dollars of both state and federal money on buyouts. New Jersey is considering post-Floyd buyouts as well. Such buyouts, or acquisition of property, are a risk-reduction activity funded under FEMA's Hazard Mitigation Grant Program (HMGP). This program uses a percentage of the federal money spent on recovering from a disaster for projects that reduce future risk, including erosion risk. By law, FEMA can contribute 15 percent of a disaster's cost to this grant program. About 20,000 properties have been purchased nationally as part of this program since 1993, but, again, few have been in coastal areas. Buyout projects, although 75 percent funded by FEMA, are administered by the state and local communities. Under the rules for buyouts funded by FEMA, the space bought out is deeded permanently as open land.

There are two advantages of a hazard mitigation acquisition program. First, acquisition offers a way to permanently reduce or eliminate susceptibility to flood damage in the highest-risk areas. Second, acquisition can be used to achieve environmental protection goals (e.g., preservation of ecologically important wetlands, maritime forest, estuarine ecosystems, and beachfront areas) and community goals (e.g., provision of open space, parks, and public beach access). Disadvantages include the substantial expense of acquisition itself and other costs, such as foregone local property taxes and long-term maintenance burden expenses, including liability (Godschalk et al., 1998). Mandatory programs also would provoke objections from private landowners.

To date, the primary purpose for land acquisition by governments at all levels and not-for-profit organizations has been to provide recreational and aesthetic opportunities and preserve natural areas. Any reduction in damage from coastal hazard is, for the most part, incidental to these programs. Through private, community, state, and federal programs of land acquisition and conservation easements, natural areas are preserved, maintained or restored; fish, wildlife, and other natural resources are protected; parks, beaches, launching ramps, and open space are provided in developed areas; deteriorating urban waterfronts are restored; and general public access to the shore is encouraged.

At the federal level, most existing programs are funded by the Land and Water Conservation Fund, which draws revenues from federal offshore oil sales. However, there is little direct acquisition of coastal property by the federal government; purchases are localized and used mainly to complete assemblages of existing national parks, seashores, and monuments.

Many states have similar acquisition programs, as do some communities and many private, non-profit land trusts. For example, North Carolina's Coastal Reserve and Public Access Program has been actively acquiring coastal areas for resource preservation, public waterfront access, and hazard mitigation purposes. Some of these projects have included the acquisition and relocation of roughly 500 residences in several coastal plain communities. A 1998 survey found that, of approximately 1,200 land trusts surveyed, 17 percent were primarily or very involved in protecting coastlines (Land Trust Alliance, 1998). The Nature Conservancy, established in 1950 to preserve endangered species, has become a major buyer of coastal property. The Conservancy buys available land and sells it mainly to government agencies that agree not to develop it, and encourages landowners to donate or voluntarily establish permanent restrictions on development through conservation easements (Dean, 1999).

In the Fiscal 2000 Omnibus Appropriations Bill (P.L. 106-113), $600 million was set aside for the Administration's Lands Legacy Initiative, including $420 million for federal land acquisition programs through the Land and Water Conservation Fund (U.S. Congress, 1999; Wilderness Society, 1999). Expanded activity also is evident in the states; Maine, for example, will hold a referendum on a $50 million bond issue for land acquisition.

Currently, there is little linkage between programs designed to acquire land for flood and erosion hazard mitigation and those that acquire coastal lands for recreational, aesthetic, and environmental protection benefits. Congress could instruct FEMA to pay increased attention to these other benefits under the HMGP, and to coordinate with other agencies to ensure that mitigation benefits are considered to an adequate degree in other land acquisition programs.

Option 9: Shoreline Protection Measures

With the exception of relocation, none of the options presented above prevent erosion damage to structures that are already built. As the shoreline moves inland, the structures and land in its path will be lost. Insurance can help compensate for these losses but clearly cannot prevent losses to houses already built. Regulatory measures may be effective in averting damage to new structures, but, again, except for relocation, they are irrelevant to owners of existing property.

The attraction of shoreline protection measures to current property owners is clear, especially in areas with a high density of existing structures and limited shoreline. As reviewed in Chapter 4, these measures include beach nourishment, dune restoration, and armoring of the shoreline with hard structures. Individuals, communities, and states already support many such projects. The federal government, primarily the U.S. Army Corps of Engineers (USACE), has been an active sponsor of shoreline protection measures. The USACE spent about $880 million between 1950 and 1993 (in 1993 dollars) on 56 individually authorized shore protection and beach erosion control projects. About $700 million of the total was for beach nourishment of about 200 miles of coast. The total cost, including the state and local shares, of the initial restoration and periodic beach nourishment, exceeded $1.1 billion (U.S. Army Corps of Engineers, 1996). Assuming an effective life of 10 years for the initial restoration, costs have averaged approximately $500,000/yr per mile. The USACE estimates that the continued maintenance and renourishment of the 200 miles will cost roughly $55–$60 million/yr, or $300,000/yr per mile of coastline.

The key questions for the present study are whether shoreline protection would alter the choice or method of implementation of the other options presented above, or vice versa. It was well beyond the scope of this study to consider the rationale and circumstances for federal funding of shoreline protection measures.

The preparation and distribution of erosion hazard maps that are part of any of the other options is likely to increase the demand for shoreline protection measures as people become more cognizant of erosion-related risks. However, the availability of maps covering all developed areas and prepared using uniform methods would allow a more systematic and equitable approach to project selection and management. In particular, such maps allow one to estimate the magnitude of erosion damage that might be avoided by beach nourishment for comparison to its costs.

Expressed as damage per year per mile, the damage estimates presented in Chapter 5 range from approximately $17,000–$480,000/yr per mile of coast. Expected annual erosion damage exceeds nourishment costs in only one of the 10 Atlantic and Gulf coast counties in The Heinz Center sample. Expected annual damage in the remaining nine counties is half of the annual cost of nourishment, or less. Although beach nourishment also provides recreation benefits, for federally funded shore protection projects built in the 1980s and 1990s, recreation benefits were about one-quarter of the total (U.S. Army Corps of Engineers, 1996). Thus, nourishment of additional stretches of the coast, if desired at all, will pass a benefit-cost test for federal funding in limited, high-density areas only. Shoreline protection measures can augment, but are not substitutes for, options such as an erosion surcharge.

A key question for FEMA, however—if Congress chooses to add an erosion surcharge to the current NFIP—is whether nourishment will lower the insurance rates paid by policyholders. Nourishment likely will reduce, but not eliminate, erosion damage. Nevertheless, the Congress still may want FEMA to ignore the presence or absence of beach nourishment when setting rates, or at least offer only modest rate reductions. Nourishment does not, after all, permanently alter erosion rates. If a community abandons a nourishment program at a later date, then it may be difficult to appropriately readjust rates. Possibly more important, builders of new homes may get the incorrect impression from reduced rates that their lots are not susceptible to erosion, and they may be encouraged to build in areas that may be subject to very high risks if, at a later date, renourishment is not pursued.

RECOMMENDATIONS

Based on the analyses presented in this report, The Heinz Center recommends that Congress take, at minimum, the following two actions. The Heinz Center believes that these two recommendations provide significant benefits, are cost effective, and are acceptable across most of the political spectrum. The other options we presented will lower damage or alleviate economic hardship should damage occur. Congress should consider the advantages and disadvantages of these options within the framework of existing Federal, State, and local programs.

Congress should instruct the Federal Emergency Management Agency to develop erosion hazard maps that display the location and extent of coastal areas subject to erosion. The erosion maps should be made widely available in both print and electronic formats.

Flood insurance rate maps do not inform current and prospective coastal property owners of erosion risks. The omission is substantial. Averaged over the highest hazard flood zone, the risk of erosion-related damage to structures is roughly equal to the risk of flood damage. Thus, the current maps, which show only flood hazards, are misleading.

Without accurate information on erosion, state and local decision makers and the general public will not be fully aware of the coastal hazards they face, nor will they be able to make use of this information for land-use planning and erosion hazard mitigation.

Congress should require the Federal Emergency Management Agency to include the cost of expected erosion losses when setting flood insurance rates along the coast.

Despite facing higher risk, homeowners in erosion-prone areas currently are paying the same amount for flood insurance as are policyholders in non-eroding areas. FEMA should incorporate the additional risk from erosion into the determination of actuarial rates in high-hazard coastal regions. This will eliminate the need for subsidies from other NFIP policyholders or taxpayers to cover expected erosion losses.

Erosion risk can be incorporated in several ways. The simplest is to combine the highest hazard flood zones and erosion hazard areas into a “Coastal High-Hazard Zone.” Erosion risk would be shared equally among all policyholders in the new combined zone. Alternatively, FEMA could charge rates based on a refined risk classification that separately distinguishes erosion and flood risks. Only those policyholders in erosion hazard areas (about one-third of the coastal high-hazard zone) would be charged an erosion surcharge.

Discussion of Recommendations

Given the magnitude of the risk posed by coastal erosion and the misleading nature of the current "flood only" coastal hazard maps, FEMA should be directed to prepare maps of erosion risks of at least the quality of current flood maps. Ideally, these maps should display both risks and be made available in both paper and electronic forms.

FEMA estimates such maps, covering 12,500 miles of U.S. ocean and Great Lakes shoreline of greatest concern, would cost approximately $44 million—less than $5 million per year over their expected 10-year useful life. While it is difficult to estimate the effect such information would have on future development decisions, the effect would not have to be large to justify the costs. If the availability of erosion maps lowers future damage by just a few percent, the savings would exceed the costs. Alternative federal erosion-related expenditures are unlikely to be more cost-effective. For example, spending an equivalent amount on beach nourishment would protect roughly another 10 miles of shoreline. And though these funds could be used to further improve existing flood maps, far less information about erosion—a risk about equal to flood in coastal regions—is available.

In addition to the use of erosion maps by individual homeowners and communities, FEMA must have them if they are to include the costs of erosion losses when setting coastal insurance rates. As presented in Chapter 5, FEMA's liability for erosion losses is likely to average $80 million per year without any further development in erosion-prone areas. If erosion hazards are not adequately factored into current flood insurance rates, losses will have to be subsidized by other NFIP policyholders or taxpayers. Losses of this level are a small fraction of the total earned premiums collected nationwide (currently about $1.3 billion per year), but within coastal regions, the percentage is substantial.

Table 6.10 includes estimates of insurance rate increases from several alternative ways to charge policy holders for the cost of erosion damage. By spreading the costs over a newly created Coastal High Hazard Zone, rates for all policy holders in both High Hazard Flood Zones (V-zones) and the 60-year Erosion Hazard Area will rise roughly $.90/year per $100 of coverage.

If Congress chooses to extend subsidies to some existing structures (similar to the current flood insurance program, which subsidizes many houses built prior to 1981), those structures would pay increases of about $.35/year per $100 of coverage.

If rate increases are confined to only those structures in the 60-year erosion hazard area, rates would have to rise by roughly $2.45/year per $100 of coverage to fully cover expected losses. Again, if Congress chooses to subsidize some (or all) current policyholders, following the percentages used elsewhere under the program would lead to rate increases of roughly $1.00/year per $100 of coverage.

Congress may prefer to treat future construction differently. Unlike the owners of existing houses, builders of new homes can choose where to locate. Congress can give builders of new homes an incentive to build further back from the shoreline within eroding areas by charging higher rates closer to the shore and lower rates further inland. Rate increases are shown for two zones, 0-20 and 20-60 years. Note that rates in the zone closest to the shoreline would have to rise to $11.40/year per $100 of coverage—over 10 percent of the value of the house each year. Rate increases in the zone set back from the shoreline could then be held to a much more modest rate, $1.75/year per $100 of coverage.

The Heinz Center's mail survey of homeowners found that about half of flood policyholders would be willing to buy optional erosion insurance at a cost less than $1-$2/year per $100 of coverage (see Figure 6.3). However, at rates exceeding $5/year per $100 of coverage, voluntary participation would be quite low. Thus, most of the rate increases shown in Table 6.10 seem within the range of public acceptability. While the rate increase for new construction closest to the shore may at first appear unreasonably high, to many homeowners it may still be preferable to such alternatives as denial of insurance, or outright bans on construction, for such risky locations.

TABLE 6.10 Insurance Rate Increases[a]

	High Hazard Flood Zone, Not EHA[b]	Erosion Hazard Area	Subsidized Rate
Combined Flood and Erosion Coastal High Hazard Zone	$0.90	$0.90	$0.35
Single Zone Erosion Hazard Area			
0- to 60-year EHA	No increase	$2.45	$0.95
Two Zone Erosion Hazard Area For New Structures			
0- to 20-year EHA	No increase	$11.40	N.A. [c]
20- to 60-year EHA	No increase	$1.75	N.A.

[a] Surcharges are given in dollars per year per $100 of coverage for a 1-4 family residence. Rates for new structures and post-1981 structures are calculated to be revenue neutral within each zone. Assumptions: Federal Insurance Administration (FIA) pays for 85 percent of damage (remainder is wind damage paid for by private insurers); interest rate is 3 percent; FIA overhead is 35 percent; subsidized structures pay 38 percent of post-81 rates.
[b] Erosion hazard area
[c] Not applicable

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GLOSSARY

AAER - Average annual erosion rate.

Accretion - May be either natural or artificial. Natural accretion is the buildup of land, solely by the action of the forces of nature, on a beach by deposition of water or airborne material. Artificial accretion is a similar buildup of land by human accretions, such as accretion formed by a groin, breakwater, or beach fill deposited by mechanical means.

A-zone - Area subject to inundation by 100-year flooding where wave action does not occur or where waves are less than 3 feet high; designated Zone A, AE, A1-A30, A0, AH, or AR on a ***Flood Insurance Rate Map.***

Armor - To protect slopes form erosion and scour by flood waters. Techniques of armoring include the use of ***riprap, gabions***, or concrete.

Base flood - Flood that has a 1-percent probability of being equal or exceeded in any given year. Also known as the 100-year flood.

Base Flood Elevation (BFE) - Elevation of the ***base flood*** in relation to a specified datum, such as the ***National Geodetic Vertical Datum.*** The Base Flood Elevation is the basis of the insurance and floodplain management requirements of the ***National Flood Insurance Program.***

Beach nourishment - Replacement of beach sand removed by ocean waters. It may be brought about naturally by longshore transport or artificially by deposition of dredged materials.

Breakaway walls - Under the ***National Flood Insurance Program***, walls that are not part of the structural support of the building and are designed and constructed to break away or collapse under specified lateral loads imposed by flood waters before transmitting damaging forces to the building and its supporting foundation system. Breakaway walls are required by the National Flood Insurance Program regulations for the portions of buildings below the ***Base Flood Elevation*** in a ***Coastal High Hazard Area***, also referred to as ***V-zones***, and are recommended in areas where flood waters could flow at significant velocities (usually greater than 4 feet per second) or could contain ice or other debris.

Breakwater - A structure protecting a shore area, harbor, anchorage, or basin from waves.

Building code - Regulations adopted by local governments that establish standards for construction, modification, and repair of buildings and other structures.

Bulkhead - Wall or other structure, often of wood, steel, or concrete, designed to retain or prevent sliding or erosion of the land. Occasionally, bulkheads are used to protect against wave action.

Coastal barrier - Depositional geologic feature such as a bay barrier, tombolo, barrier spit, or barrier island that consists of unconsolidated sedimentary materials; is subject to wave, tidal, and wind energies; and protects landward aquatic habitats from direct wave attack.

Coastal Barrier Resource Act of 1982 (CBRA) - Act (Pub. L. 97-348) that established the Coastal Barrier Resources System. The act prohibits the provision of new flood insurance coverage on or after October 1, 1983, for any new construction or substantial improvements of structures located on any designated undeveloped coastal barrier within the Coastal Barrier Resources System.

Coastal flood hazard area - Area, usually along an open coast, bay, or inlet, that is subject to inundation by storm surge and, in some instances, wave action caused by storms or seismic forces.

Coastal High Hazard Area - Area of special flood hazard, designated Zone V, VE, or V1-V30 on a ***Flood Insurance Rate Map*** that extends from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high-velocity breaking waves of 3 feet or more in height caused by storms or seismic forces.

Coastline - (1) Technically, the line that forms the boundary between the coast and the shore. (2) Commonly, the line that forms the boundary between the land and the water.

Development- Under the ***National Flood Insurance Program***, any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations or storage of equipment or materials.

Downdrift - The direction of predominant movement of littoral materials.

E-zone - An area along the coast where waves and other forces are anticipated to cause significant erosion within the next 60 years and may result in the damage or loss of buildings and infrastructure.

Episodic erosion - ***Erosion*** induced by a single storm event. Episodic erosion considers the vertical component of two factors: general beach profile lowering and localized conical scour around foundation supports. Episodic erosion is relevant to foundation embedment depth and potential undermining.

Erosion - Wearing away of the land surface by detachment and movement of soil and rock fragments, during a flood or storm or over a period of years, through the action of wind, water, or other geologic processes.

Erosion Hazard Area (EHA) – Area anticipated to be lost to shoreline retreat over a given period of time. The projected inland extent of the area is measured in years times the average annual long-term recession rate.

Federal Emergency Management Agency (FEMA) - Independent agency created in 1978 to provide a single point of accountability for all Federal activities related to disaster mitigation and emergency preparedness, response and recovery. FEMA administers the ***National Flood Insurance Program***.

Federal Insurance Administration (FIA) - The component of the ***Federal Emergency Management Agency*** directly responsible for administering the flood insurance aspects of the ***National Flood Insurance Program***.

FIRM – see ***Flood Insurance Rate Maps***.

FIS – see ***Flood Insurance Study*.**

Flood - Under the ***National Flood Insurance Program***, a general and temporary condition or partial or complete inundation of normally dry land areas from (1) the overflow of inland or tidal waters, (2) the unusual and rapid accumulation or runoff of surface waters from any source, or (3) mudflows or the sudden collapse of shoreline land.

Flood depth - Height of the flood water surface above the ground surface.

Flood elevation - Height of the water surface above an established elevation datum, e.g., ***National Geodetic Vertical Datum, North American Vertical Datum, Mean Sea Level.***

Flood hazard area - The greater of the following: (1) the ***Special Flood Hazard Area*** or (2) the area designated as a flood hazard area on a community's legal flood hazard map, or otherwise legally designated.

Flood Insurance - Insurance coverage provided under the ***National Flood Insurance Program.***

Flood Insurance Rate Map (FIRM) - Map of a community, prepared by the ***Federal Emergency Management Agency***, that shows both the special hazard areas and the risk premium zones applicable to the community. The latest FIRM issued for a community is referred to as the "effective" FIRM.

Flood Insurance Study (FIS) - Examination, evaluation, and determination of flood hazards and, if appropriate, corresponding water surface elevations in a community or communities, or examination, evaluation, and determination of mudslide (i.e., mudflow) and/or flood-related erosion hazards in a community or communities.

Flood-related erosion area or flood-related erosion prone area - Land area adjoining the shore of a lake or other body of water which, because of the composition of the shoreline or bank and high water levels or wind-driven currents, is likely to suffer damage from ***erosion*** caused by flood forces.

Floodplain - Any land area, including watercourse, susceptible to partial or complete inundation by water from any source.

Floodplain management - Operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to emergency preparedness plans, flood control works, and floodplain management regulations.

Frontal dune - Ridge or mound of unconsolidated sandy soil, extending continuously alongshore landward of the sand beach and defined by relatively steep slopes abutting markedly flatter and lower regions on each side.

Groin - A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore.

High-velocity wave action - Condition in which wave heights are greater than or equal to 3.0 feet or wave runup elevations reach 3.0 or more feet above grade.

Hurricane - Tropical cyclone, formed in the atmosphere over warm ocean areas, in which wind speeds reach 74 miles per hour or more and blow in a large spiral around a relatively calm center or "eye." Hurricane circulation is counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

Jetty - A structure extending into a body of water, designed to prevent shoaling of a channel by littoral materials and to direct and confine the stream or tidal flow. Jetties are built at the mouths of rivers or tidal inlets to help deepen and stabilize a channel.

Littoral - Of or pertaining to the shore, especially of the sea.

Littoral Drift - Movement of sand by littoral (longshore) currents in a direction parallel to the beach along the shore.

Littoral Transport - The movement of littoral drift in the littoral zone by waves and currents. Includes movement parallel and perpendicular to the shore.

Lowest floor - The lowest floor of the lowest enclosed area (including basement) of a structure. An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access, or storage in an area other than a basement, is not considered a building's lowest floor.

Mean High Water - The average height of the high waters over a 19-year period.

Mean Sea Level (MSL) - Average height of the sea for all stages of the tide, usually determined from hourly height observations over a 19-year period on an open coast or in adjacent waters having free access to the sea. See ***National Geodetic Vertical Datum***.

National Flood Insurance Program (NFIP) - Federal program created by Congress in 1968 that makes flood insurance available in communities that enact satisfactory floodplain management regulations.

National Geodetic Vertical Datum (NGVD) - Datum established in 1929 and used as a basis for measuring flood, ground, and structural elevations, previously referred to as Sea Level Datum or ***Mean Sea Level***. The ***Base Flood Elevations*** shown on most of the ***Flood Insurance Rate Maps*** issued by the ***Federal Emergency Management Agency*** are referenced to NGVD.

100-year flood - See ***Base Flood***.

Post-FIRM - For insurance purposes, post-FIRM construction in a given community is construction or substantial improvement of a structure that began after December 31, 1974, or on or after the effective date of the first ***Flood Insurance Rate Map*** for the community, whichever is later. For floodplain management purposes, post-FIRM construction in a given community means structures for which the start of new or substantial improvement construction began before the effective date of the floodplain management regulation adopted by the community.

Primary frontal dune - Continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope.

Retrofit - In floodproofing, any change made to a structure designed to reduce or eliminate damage to that structure from flooding erosion.

Revetment – A facing of stone, cement, sandbags, or other materials built to protect a scarp, embankment, or short structure against erosion or scour caused by flood waters or wave action.

Sand dunes - Natural or artificial ridges or mounds of sand landward of the beach.

Sand wave - A large wavelike sediment feature composed of sand in very shallow water. Wavelength may reach 100 meters; amplitude is about 0.5 meter.

Scarp - An almost vertical slope along the beach caused by erosion by wave action. It may vary in height from a few centimeters to a meter or so, depending on wave action and the nature and composition of the beach.

Scour – Removal of soil or fill material by the flow of flood waters. The term is frequently used to describe storm-induced, localized conical erosion around pilings and other foundation supports where the obstruction of flow increases turbulence. See ***erosion***.

Seawall - A structure separating land and water areas, primarily designed to prevent erosion and other damage from wave actions.

SFHA – See ***Special Flood Hazard Area***.

Shear wall - Load-bearing or non-load-bearing wall that transfers in-plane lateral forces from lateral loads acting on a structure to its foundation.

Shore - The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines. A shore of unconsolidated material usually is called a beach.

Shoreline - The intersection of a specified plane of water with the shore or beach. The line delineating the shoreline on natural ocean service nautical charts and survey approximates the mean high water line.

Shoreline retreat - Progressive movement of the shoreline in a landward direction caused by the composite effect of all storms considered over decades and centuries (expressed as an annual average erosion rate). Shoreline retreat considers the horizontal component of erosion and is relevant to long-term land use decisions and the siting of buildings.

Special Flood Hazard Area (SFHA) – An area within a floodplain having a 1 percent or greater chance of flood occurrence in any given year (100-year floodplain); represented on ***Flood Insurance Rate Maps*** by darkly shaded areas with zone designations that include the letter A or V.

Storm surge - Rise in the water surface above normal water level on the open coast due to the action of wind stress and atmospheric pressure on the water surface.

Structure - Under the ***National Flood Insurance Program***, a walled and roofed building, including a gas or liquid storage tank, that is principally above ground, as well as a manufactured home; for insurance coverage purposes.

Substantial damage - Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage.

Substantial improvement - Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the ***start of construction*** of the improvement. This term includes structures, which have incurred ***substantial damage***, regardless of the actual repair work performed.

Surge - See ***Storm surge***.

Tsunami - Great sea wave produced by submarine earth movement or volcanic eruption.

Undermining - Process whereby the vertical component or erosion or scour exceeds the depth of the base of a building foundation or the level below which the bearing strength of at the foundation is compromised.

Updrift - The direction opposite that of the predominant movement of littoral materials.

V-zone - also known as *Coastal High Hazard Area*. Flood hazard zone that corresponds to the 100-year floodplain that is subject to high velocity wave action from coastal storms or seismic sources; designated Zone VO, V1-30, VE, or V on a *Flood Insurance Rate Map*.

Water surface elevation - Height of the water surface above an established elevation datum, e.g., *National Geodetic Vertical Datum*, *North American Vertical Datum*, *Mean Sea Level*, reached by floods of various magnitudes and frequencies in the floodplains of coastal, lacustrine, and riverine areas.

Wave height - Vertical distance between a wave crest and the preceding trough.

Wind tide – The vertical rise in the stillwater level on the leeward side of a body of water caused by wind stresses on the surface of the water.

X-zone – A flood hazard zone outside the 100-year floodplain, which have moderate to minimal risk. Older maps differentiate the X zone into Zones B and C, which represent moderate and minimal flood risks, respectively.

Zone – A geographical area shown on a ***Flood Insurance Rate Map (FIRM)*** that reflects the severity or type of flooding in the area.

LIST OF ACRONYMS

CBRA	(Coastal Barrier Resources Act)
CBRS	(Coastal Barrier Resources System)
CRS	(Community Rating System)
CZMA	(Coastal Zone Management Act)
CZM	(Coastal Zone Management)
EHA	(Erosion Hazard Area)
FEMA	(Federal Emergency Management Agency)
FIA	(Federal Insurance Agency)
FIRM	(Flood Insurance Rate Map)
GIS	(Geographic Information System)
GPS	(Global Positioning System)
HUD	(Department of Housing and Urban Development)
ICC	(Increased Cost of Compliance)
IPCC	(Intergovernmental Panel on Climate Change)
IRC	(Insurance Research Council)
NFIA	(National Flood Insurance Act)
NFIF	(National Flood Insurance Fund)
NFIP	(National Flood Insurance Program)
NFIRA	(National Flood Insurance Reform Act)
NOAA	(National Oceanic and Atmospheric Administration)
NPS	(National Park Service)
NRC	(National Research Council)
SBA	(Small Business Administration)
SDI	(Spatial Data Institute)
SFHA	(Special Flood Hazard Area)
UNCED	(United Nations Conference of Environment and Development)
USACE	(U.S. Army Corps of Engineers)
USEPA	(U.S. Environmental Protection Agency)
USFWS	(U.S. Fish and Wildlife Service)
USGS	(U.S. Geological Survey)

BIOGRAPHICAL SKETCHES

STEERING COMMITTEE

Stephen Leatherman, Chair, is Professor and Director of Florida International University's Laboratory for Coastal Research & International Hurricane Center. Dr. Leatherman is a nationally recognized expert in coastal erosion analysis, computerized mapping of historical shoreline changes, and sea-level rise impact assessments. He has worked directly with FEMA on numerous occasions, most recently as a key participant in FEMA's pilot "economic impact analysis" study in Sussex County, Delaware. Along with Mark Crowell of FEMA, Dr. Leatherman was the co-editor of the recently published book "Coastal Erosion Mapping and Management" (1999, Journal of Coastal Research Special Issue). He has also regularly provided testimony on erosion-related issues to the U.S. Congress and served as a technical advisor to policymakers, including drafters of the Upton-Jones Bill (part of the U.S. Housing Act of 1987). Dr. Leatherman has authored or edited 14 books and over 100 journal articles and reports. He received his B.S. in Geosciences from North Carolina State University and his Ph.D. in Environmental (Coastal) Science from the University of Virginia.

Jeffrey R. Benoit is the Director of the National Oceanic and Atmospheric Administration's (NOAA) Office of Ocean and Coastal Resource Management (OCRM). His responsibility encompasses three major programs for coastal and marine stewardship: National Coastal Zone Management, National Estuarine Research Reserves, and National Marine Sanctuaries. During his tenure as OCRM Director, Mr. Benoit revitalized the National CZM Program, championing its first expansion in over 10 years; secured state acceptance of management plans for the Florida Keys and the Hawaiian Islands Humpback Whale national marine sanctuaries sanctuaries; and steered the process that created the Jacques Cousteau National Estuarine Research Reserve at Mullica River-Great Bay in New Jersey. Mr. Benoit has furthered discussions of important marine issues in scientific communities around the world, and often testifies before Congress. He chaired NOAA's Sustain Healthy Coasts strategic planning team from 1994 to 1997, and chaired one of five Working Groups established by the US Coral Reef Task Force created in 1998. Prior to accepting his position at OCRM, Jeff served as Coastal Geologist and later Director of Massachusetts CZM Program. He received his B.S. in Marine Geology from Southampton College and Master's Degree in Geophysical Science from Georgia Institute of Technology.

Michael Buckley is the Division Director, Hazard Identification and Risk Assessment Division, Mitigation Directorate, US Federal Emergency Management Agency (FEMA). In this capacity, he is responsible for a broad range of activities and programs to identify and assess risk from all natural hazards, with an emphasis on floods and flood-related hazards, earthquakes, hurricanes, and wind. Major programs include the Hazard Mitigation Grant Program, National Flood Insurance Program, Hurricane Program, and Dam Safety Program. Prior to joining FEMA in 1980, Mr. Buckley worked with a public and private consulting engineering practice on a broad range of responsibilities involving water resources engineering and land development.

Michael J. Colvin is a Manager with the Ohio Department of Natural Resources (ODNR) responsible for developing and implementing Ohio Coastal Management Program. Mr. Colvin serves as Ohio's delegate to the national Coastal States Organization (CSO), and chairs the Coastal Hazards Committee. He serves on the Ohio Maritime Advisory Council, helping shape public policy for protecting and utilizing underwater resources including shipwrecks. Prior to his position with the Ohio Coastal Management Program, Mr. Colvin served as ODNR’s Environmental Review Administrator. He has prepared and co-authored various publications. These include the Ohio Coastal Management Program document and environmental impact statement (U.S. Department of Commerce, NOAA and ODNR, March 1997), the Ohio Wetlands Priority Conservation Plan (ODNR, 1987), ODNR Wetlands Policy (September, 1989), and Governor’s Executive Order 90-68 on the Protection of Wetlands (October, 1990). He served on the Ohio Supreme Court’s Board of Commissioners of the Client Security Fund 1992-1997, serving as Vice Chair during 1996-97. Mr. Colvin holds a B.S. in Zoology and M.A. in Public Administration, with a specialty in Urban Administration from The Ohio State University.

Margaret Davidson is the Director of the National Oceanic and Atmospheric Administration’s (NOAA) Coastal Services Center. Ms. Davidson has been active in coastal resource management and economic issues since 1978. Her professional work has focused on mitigation of coastal hazards, impacts of climate variability on coastal resources, and environmentally-sustainable aquaculture. Her early experience as a lawyer in Louisiana combined with a Master’s degree in Marine Affairs/Economics caused her to shepherd development of a hazards initiative for the National Sea Grant Program. Recent efforts to coordinate development of a NOAA-wide Hazards Initiative have contributed to the implementation of a series of local level hazards risk and vulnerability indices with the USGS and state and local partners in Alabama, North Carolina, Florida and Ohio.

William G. Fry has served for over four years as the Chief Executive Officer of Spatial Data Institute, LC., a nationwide consortium of six mapping technology firms. In this capacity he directed the joint performance of the SDI Partner Firms in the extremely successful Mississippi River Project, mapping over two million acres of the U.S. Mid-West floodplains for the Corps of Engineers and US Geological Survey. Among other accomplishments of this innovative project, over 4,000 man-hours of GPS surveying was completed. Prior to founding SDI, Fry served as the Project Manager of a Technical Evaluation Contract to the NFIP for over twenty years, and as the Project Director to FEMA's Disaster Assistance Program's Technical Assistance Contract for over twelve years. In these capacities, Fry led major field operations, including mapping and surveying, provided program consultation to FEMA, and directed over 200 technical and service personnel dedicated to FEMA initiatives. Fry received a B.S.Civil Engineering from Duke University in 1969. He possesses thirty years of civil engineering and mapping experience.

Robert W. Kates, a Senior Fellow with The Heinz Center, is University Professor *Emeritus* at Brown University, executive editor of *Environment Magazine* and distinguished scientist at the George Perkins Marsh Institute at Clark University. Dr. Kates is an independent scholar with a wide range of expertise in geography, demographic trends, and technological and natural hazards. Previous research includes natural hazards mitigation and adaptation, rural resource and water development, the assessment of risk, and the impacts of climate on society. Dr. Kates is author, editor, or co-editor of 20 books and monographs, and is the recipient of the 1991 National Medal of Science awarded by the President of the United States and the MacArthur Prize Fellowship (1981-1985). He received his Ph.D. in geography from the University of Chicago.

Howard Kunreuther is the Cecilia Yen Koo Professor and Chairperson of the Operations and Information Management Department at The Wharton School at the University of Pennsylvania. He also serves as Co-Director of the Risk Management and Decision Processes Center. His participation on the steering committee brings special expertise in the areas of managing risk through loss reduction methods and risks spreading techniques such as insurance. He focuses on how insurance regulatory and liability questions affect risk-management decisions, an issue important to this project. Dr. Kunreuther will bring risk management and business management of risk to the table in the discussions of this group related to erosion mapping and land-use planning. He is a recipient of the Elizur Wright Award for the publication that makes the most significant contribution to the literature of insurance and is a Distinguished Fellow of the Society for Risk Analysis. Dr. Kunreuther received his A.B. from Bates College and holds a Ph.D. in Economics from the Massachusetts Institute of Technology.

Thomas Malone is Executive Scientist, Connecticut Academy of Science and Engineering, University Distinguished Scholar, North Carolina State University, and Senior Advisor and a Past President, Sigma Xi, The Scientific Research Society. Dr. Malone left a tenured faculty position at MIT and joined the Travelers Insurance Companies where he became a Senior Vice President and Director of Research. His Travelers' experience provided him with a good understanding of the complexities and nuances of actuarial work and risk assessment. Elected a member of the National Academy of Sciences in 1968, he served as the Academy's Foreign Secretary from 1978 to 1982. Former Dean of the Graduate School at the University of Connecticut, he received his SB from the South Dakota School of Mines & Technology and his ScD from MIT. The American Association for the Advancement of Science and the World Meteorological Organization have honored him for his contributions to international interdisciplinary activities. He is the recipient of the Waldo E. Smith Medal from the American Geophysical Union "for extraordinary service to geophysics."

Rutherford Platt is a professor of geography and planning law at the University of Massachusetts in Amherst. He specializes in the management of land and water resources and has focused much of his research on problems of floodplain, wetland and coastal management. Before coming to the University of Massachusetts in 1972, Dr. Platt spent four years as staff attorney for the Open Lands Project, where he specialized in advocacy of open space preservation, farmland conservation, and highway and power plant siting. He has served on numerous National Research Council committees, including the Committee on Coastal Erosion Zone Management, the Committee on Flood Insurance Studies, and the Committee on Water Resources Research Review. He holds a JD from the University of Chicago Law School and a Ph.D. in geography from the University of Chicago. He is the author of several books, most recently “Disasters and Democracy: The Politics of Extreme Natural Events.”

Francis V. Reilly retired from federal service in 1993 and currently provides flood insurance consulting services. From 1980 to his retirement, he served as Deputy Administrator and Chief Actuary of the Federal Insurance Administration, the Directorate in FEMA which administers the National Flood Insurance Program, Riot and Civil Commotion Reinsurance Program, and the Federal Crime Insurance Program. From 1973 to 1979, Mr. Reilly served as the Assistant Administrator and Actuary of the Federal Insurance Administration; from 1951 to 1972, he served as Actuary and Mgr. of the Actuarial Dept. of the Mutual Insurance Rating Bureau from 1966-72; as Assistant Actuary from 1964-66; and was a member of Actuarial Department from 1951-64. He received the rank of Distinguished Executive in the Senior Executive Service from President Ronald Reagan in 1988 and the rank of Meritorious Executive in the Senior Executive Service in 1986. He has been a member of the American Academy of

Actuaries since 1967. Mr. Reilly received his B.S. Degree in Mathematics from St. Francis College, Brooklyn, NY.

Richard Roth, Sr. is a private consultant who has almost 50 years of insurance experience. He has been the Chief Actuary of the American International Group, Senior Vice President and Actuary of the Great American Insurance Companies, and Vice President and Actuary of the CNA Insurance Companies. He is a Fellow of the Casualty Actuarial Society. He was the first Chairman of the Federal Insurance Administration's "Write Your Own" Standards Committee for the National Flood Insurance Program and has received FEMA's Outstanding Public Service Award. Mr. Roth received his Honors Degree in Economics from Northwestern University, and was elected to Phi Beta Kappa.

John Sawhill is Chairman of The Heinz Center's Board of Trustees and President and Chief Executive Officer of The Nature Conservancy. Prior to joining The Nature Conservancy, he served as a director of McKinsey & Company, Inc. and headed the firm's energy consulting practice from 1981-1990. Sawhill also served as Deputy Secretary of the Dept. of Energy under President Carter. During the Nixon and Ford Administrations, he served as Administrator of the Federal Energy Administration; Deputy Administrator of the Federal Energy Office; and Associate Director for Natural Resources, Energy, Science, and Environment of the Office of Management and Budget. He is a member of numerous federal advisory panels, including the President's Council on Sustainable Development and the EPA's National Advisory Committee on Public Policy and Technology. Dr. Sawhill received his BA from Princeton University and holds a Ph.D. in Economics from New York University.

V. Kerry Smith is the University Distinguished Professor, Dept of Agricultural and Resource Economics, North Carolina State University. He is also Director of the Center for Environmental and Resource Economic Policy at NCSU, and a University Fellow of Resources for the Future. He is a leading environmental and natural resource economist. He has authored 12 books and over 200 articles and notes. He is a past president of the Association of Environmental and Resource Economists as well as recipient of their Distinguished Service Award. In addition to many other areas of research, he has investigated the relationship between beach characteristics and rental values in the Outer Banks of North Carolina, one of the areas included in this study. Dr. Smith received his A.B and Ph.D. in economics from Rutgers University.

Gilbert White is Professor Emeritus of Geography at the University of Colorado and former Director of the Natural Hazards Research Applications and Information Center. Dr. White is known internationally for his work with natural hazard planning and adaptation and his research into floodplain management and coastal resource policy. He is widely recognized as a founding father of national floodplain policy, and he has been active with various aspects of national management since publication of his Human Adjustment to Floods in l945, and of the task force report which he chaired on a Unified National Program for Managing Flood Losses in 1966. Dr. White has chaired several national advisory boards, committees and federal task forces concerned with floodplain policy and resource management, and is the author of numerous journal articles and technical reports. Dr. White received his S.B., S.M., and Ph.D. from the University of Chicago.

Robert White, a Senior Fellow with The Heinz Center, brings to this issue his broad knowledge of oceanic and environmental affairs from his work as Administrator of the National Oceanic and Atmospheric Administration and more recently as President of the National Academy of Engineering. Dr. White served as Administrator of NOAA during the formative years of the coastal management program and early implementation of the distributed approach to management of the nations coast. This is analogous to the approach FEMA is taking with local level implementation of erosion mapping and he will provide critical intellectual framing to ensure this erosion mapping study includes the local level implementation. He has served under five presidents from 1963 to which provided an excellent framework for understanding policy options. Dr. White received his BA in from Harvard University and his MS and ScD degrees in meteorology from the Massachusetts Institute of Technology.

THE HEINZ CENTER PROJECT STAFF

William J. Merrell, Jr. is the President and Senior Fellow of The Heinz Center. Prior to joining The Heinz Center, Dr. Merrell was Vice Chancellor for Strategic Programs of The Texas A&M University System. He continues to hold the appointment of Professor of Oceanography at Texas A&M University. He has published scientific papers on many aspects of marine sciences, and serves on several national advisory boards and committees concerned with ocean resources. Dr. Merrell received his BS and MA degrees from Sam Houston State University and a Ph.D. in oceanography from Texas A&M University. Dr. Merrell has received the Distinguished Member Award for Research Achievement from the Texas A&M University Chapter of Sigma Xi, the Distinguished Achievement Award from the Geosciences and Earth Resources Council, and the Distinguished Service Award of the National Science Foundation. He is a Rear Admiral (Retired) in the United States Maritime Service.

Stephen V. Dunn is Deputy Project Manager for The Heinz Center's "Evaluation of Erosion Hazards" study. His experience includes work in coastal hazards analysis, global change, and environmental policy. He has worked in government, environmental organizations, and universities on environmental issues. Mr. Dunn received his BA in environmental studies from the University of California at Santa Cruz and his MES from the School of Forestry and Environmental Studies, Yale University.

Robert M. Friedman is the Vice President for Research and Senior Fellow at The Heinz Center. Prior to joining The Heinz Center, Dr. Friedman was a Senior Associate at the Office of Technology Assessment, U.S. Congress. For 15 years, he advised Congressional committees on issues involving environmental, energy, transportation, and natural resources policy. He directed major policy research efforts on acid deposition, urban ozone, and climate change, among other issues. His most recent assessment evaluated alternative approaches to environmental policy, including traditional regulatory approaches, market-based mechanisms, and non-regulatory measures. Dr. Friedman received his BA from The Johns Hopkins University and his Ph.D. from the University of Wisconsin, Madison in ecological systems analysis. He is a Fellow of the American Association for the Advancement of Science and a recipient of OTA's Distinguished Service Award.

Sheila D. David is a Fellow and Project Manager at The Heinz Center where she is currently managing studies for the Center's Sustainable Oceans, Coasts, and Waterways program. Prior to joining The Heinz Center in 1997, she was a Senior Program Officer at the National Academy of Science's Water Science and Technology Board for 21 years where she was the study director for approximately 30 committees that produced reports on topics such as Managing Coastal Erosion, The Restoration of Aquatic Ecosystems, Protection of Ground Water, Wetlands Characteristics and Boundaries, Water Quality and Water Reuse, Natural Resource Protection in the Grand Canyon and Sustainable Water Supplies in the Middle East. Ms. David has served as an advisor and board member of the Association for Women in Science (AWIS) and as editor of AWIS magazine. She is also a founder of the National Academy of Science's Annual Program honoring Women in Science.

Sarah K. Baish is a research assistant for The Heinz Center's Sustainable Oceans, Coasts, and Waterways program. Prior to joining The Heinz Center, she worked in a national park in Slovakia as a Environmental Management Consultant with the U.S. Peace Corps. Her primary responsibilities included grant writing, organizing educational events, promoting interpretive visitor services, and facilitating international collaborations. Previously, she interned with the National Oceanic and Atmospheric Administration, and her work contributed to the establishment of a humpback whale sanctuary in Hawaii. Ms. Baish received her B.A. in environmental science and is working towards a masters in urban planning from the University of Virginia.

Allison Sondak, now attending law school at Tulane University, was a research assistant for the Sustainable Oceans and Coasts program. Prior to working at The Heinz Center, she was a project assistant for the National Academy of Science's Board on Biology. She worked previously on fisheries and environmental policy for the U.S. Senate and on park management at the National Park Service. Her interests include coastal zone policy and natural resource management. She received a B.A. in environmental policy at Duke University and studied marine science and policy at the University of Copenhagen, Denmark.

MAJOR CONSULTANTS

Joseph J. Cordes is a Professor of Economics and the Director of the Ph.D. Program in Public Policy at The George Washington University. He is currently a Visiting Fellow at the Urban Institute. He was Associate Dean for Faculty Affairs and Programs in the Columbian College of Arts and Sciences at The George Washington University from 1986 to 1989, and Chair of the Department of Economics from 1991 to 1997. Previously, he was a Brookings Economic Policy Fellow in the Office of the Assistant Secretary for Tax Policy, United States Treasury Department as well as Deputy Assistant Director for Tax Analysis at the Congressional Budget Office. He is a co-editor of the *Encyclopedia of Taxation and Tax Policy* (Urban Institute Press, 1999), and *Democracy, Social Values and Public Policy* (Greenwood-Praeger, 1998). He has published over fifty articles on tax policy, government regulation, government spending, and nonprofit organizations. Along with Anthony Yezer, Dr. Cordes researched the question of whether shore protection and beach erosion control projects sponsored by the Army Corps of Engineers changed the rate of housing development in communities where the projects are located. The results of this research were published in the February 1998 issue of *Land Economics*. Dr. Cordes received his BA in economics from Stanford University and his MS and Ph.D. in economics from the University of Wisconsin, Madison.

Andrew Keeler is Associate Professor of Agricultural and Applied Economics at the University of Georgia. Dr. Keeler's general research interests are in the area of implementation and enforcement of environmental policy. Recent research on coastal land issues in Glynn County, Georgia, compared the benefits of hard stabilization, beach nourishment, and retreat, as perceived by property owners, businesses, and beach visitors. Previously, Dr. Keeler worked for the United Nations in Dar-es-Salaam, Tanzania. Dr. Keeler received his BA from the University of North Carolina and his Ph.D. in Natural Resource Economics from the University of California at Berkeley.

Warren Kriesel is Associate Professor of Agricultural and Applied Economics, University of Georgia. In earlier research, Kriesel has estimated the effect of shore erosion on property values on the Ohio shoreline of Lake Erie. His current research in Glynn County Georgia compares the benefits of hard stabilization, beach nourishment, and retreat, as perceived by property owners, businesses, and beach visitors. Dr. Kriesel received his BS from the University of Wisconsin and his Ph.D. in Agricultural Economics from Ohio State University.

Craig E. Landry is a recipient of the Arthur A. and Pauline Seidenspinner Graduate Fellowship at the University of Maryland, College Park, where he is currently working on his Ph.D. in Environmental and Resource Economics. His research interests include sustainable development, coastal geomorphology, coastal hazards, risk and uncertainty, and global climate change. He received his B.S.A. and M.S. from the University of Georgia in Environmental Economics and Management.

Susanne C. Moser is a staff scientist in the Global Resources Program of the Union of Concerned Scientists. She manages UCS's work on climate change impacts, is a team member of the organization's Sound Science Initiative, and continues to be involved with the U.S. National Assessment of the Potential Impacts of Climate Variability and Change. Prior to her work with UCS, Dr. Moser was a post-doctoral fellow for two years at Harvard's Kennedy School of Government and a fellow at the Center for the Integrated Study of the Human Dimensions of Global Change at Carnegie Mellon University. She investigated the impact of scientific assessments of global environmental change on national and local policy-making, and the transfer of environmental knowledge across scale. Her research focus over the past several years has been on environmental hazards—in particular coastal hazards like storms, floods, sea-level rise, and erosion—as a result of global climatic change. In 1995, she received a NSF dissertation award for her research on the human sources of uncertainty and ignorance in the context of sea-level rise impacts and policy-making. She worked with the Heinz Center on the Evaluation of Erosion Hazards project, investigating the NFIP policy context and community responses to coastal erosion. Dr. Moser was trained as an Earth scientist at the University of Trier, Germany, and received her Ph.D. in Geography from Clark University in Worcester, MA.

George Parsons is a Professor of Economics at University of Delaware. He received his Ph.D. from the University of Wisconsin. His research centers on environmental economics with a focus on valuation. He has conducted studies recently on the effects of coastal land use restrictions on property values and on the economics of beach use. He has served as an editor for the Journal of Environmental Economics and Management and Marine Resource Economics.

Hugh Phillips is a GIS Analyst for 3001, Inc. Prior to that he worked for the University of Wisconsin-Madison General Library System to establish GIS capabilities and resources through the library computer network. He also worked for Wisconsin State Cartographer's Office and helped establish Wisconsin's NSDI Clearinghouse node. Dr. Phillips is active in forums and workshops concerning the federal metadata standard and has helped build metadata into the data processing stream at 3001, Inc. He has a Ph.D. in Chemistry from the University of Arizona and masters degree in Cartography and GIS from the University of Wisconsin-Madison.

Richard Roth, Jr. is the Chief Property and Casualty Actuary for the Department of Insurance, State of California. Mr. Roth specializes in the financial examination of insurance companies, reinsurance, workers compensation, automobile insurance, and insurance against natural hazards, especially earthquake insurance. In addition, he is a Fellow of the Casualty Actuary Society and currently serves on the Board of Directors. Currently, Mr. Roth is very active in the National Association of Insurance Commissioners (NAIC). Mr. Roth is the Chairman of the Casualty Actuarial (Technical) Task Force at the NAIC, which is the permanent committee at the NAIC overseeing casualty actuarial issues. He is also active on the two catastrophe insurance committees addressing catastrophe insurance issues for all types of insured natural disasters. He has testified on natural disaster and earthquake insurance before both the California State Legislature and the US Congress. He received his BS in Mathematics, MS in Statistics and MA in Economics from Stanford University.

William A. Seitz was a Professor of Oceanography (Chemistry, Computer Science) from 1977 to 1988. Dr. Seitz carries out research in chemistry, oceanography and environmental policy. His chemical work (funded by the Welch Foundation and ATP/ARP grants as well as industrial support) includes fundamental theories of large molecular systems and studies of the activities of nitric oxide in living tissue. The latter work is being carried out in collaboration with the University of Texas Medical Branch and has led to the development of three patents and formation of a biotechnology start-up company. The oceanography research (funded by Sea Grant) involves computer modeling of estuarine circulation using methods developed by complexity theorists for use in commercial oil-spill simulators. Dr. Seitz is a Senior Fellow at the H. John Heinz III Center for Science, Economics and the Environment in Washington, DC where he conducts research on policy responses to coastal erosion hazards. He received his BA from Rice University in 1970 and his Ph.D. from the University of Texas at Austin in 1973. His graduate appointment was in Oceanography.

Russell Watkins, Ph.D., is the Director of Research and Development at 3001, Inc. in the Gainesville, Florida office. He served as the Geographic Information Systems Development and Applications project manager for this study. Dr. Watkins has over 15 years of international experience with automated mapping systems. His systems have served state, local and federal clients, as well as private industry. He has extensive knowledge in all widely used commercial GIS platforms, and has significant experience in training users. Dr. Watkins has made numerous presentations on topics related to geographic information systems, remote sensing techniques and landscape ecology. He has produced technical reports and peer-reviewed articles as well as providing instructional workshops for government and corporate personnel. Dr. Watkins received his doctorate in Geography and Geomatics from the University of Florida. He has been awarded postdoctoral fellowships from the Geography Department at the University of Auckland, Auckland, New Zealand and the Center for Environmental Studies at Arizona State University, Tempe, Arizona.

Anthony Yezer is professor of Economics, George Washington University. He specializes in Regional and Urban Economics, Real Estate Finance, and Applied Microeconomics. Along with Joseph Cordes, Dr. Yezer researched the question of whether shore protection and beach erosion control projects sponsored by the Army Corps of Engineers changed the rate of housing development in communities where the projects are located. Dr. Yezer received his BS in Economics from Dartmouth, M.Sc. in Economics from the London School of Economics and Political Science, and Ph.D. in Economics and Urban Studies from the Massachusetts Institute of Technology.